INDUSTRIAL MANAGEMENT

ELEMENTS OF SUPERVISION

By WILLIAM R. SPRIEGEL and EDWARD SCHULZ.
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SPRIEGEL AND LANSBURGH

INDUSTRIAL MANAGEMENT

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PREFACE TO THE FOURTH EDITION

When the late Richard H. Lansburgh wrote the first edition of this book in 1923, he established a pattern that has been rigidly followed in each subsequent edition. Our purpose has been to establish a balance between theory and practice and to have the theory an outgrowth or projection of successful practice rather than pure abstraction.

It has been our aim to keep both the college student and the executive in mind as each chapter was written. The college student desires to learn the latest practices and the theory behind them, and the executive is interested in suggestions that may help him solve his current problems. Throughout the book an effort has been made to show the relationships and the interdependence of the various major departments of a business. The policies and principles of successful management and the devices to carry them out are presented. Without these no management, however clearly conceived, can be successful.

Although the philosophy on which this book is based includes a belief in private enterprise and in individual initiative and responsibility, the importance of group effort is fully acknowledged. It is recognized that management has a responsibility to the community, the consumers, the employees, the owners, and organized government. Scientific management strives to harmonize the various interests involved in the productive process. Business relationships have been treated with the belief that faith must be created in modern business—faith of the management in the employee, and faith of the employee in the management. These relationships have been presented with the thought that worth-while management must be courageous and willing to lead, but must be always careful lest unprofitable experiments discourage future attempts to improve management methods.

Throughout the book the central purpose has been to present a unified treatise. The technical sections of Chapters X, XIV, XV, and XVI are presented as general information; it is not expected that the average student will master these technical details.

Sound managerial principles are universally applicable; hence the illustrations have been selected from a variety of industries. In the main, the text has been developed from the point of view of the medium-

sized plant, but frequent reference has been made to the large and the small enterprise. Since the basic principles and policies which have been laid down are applicable everywhere, only the systems and devices which put them into effect need be modified as the size of the plant changes.

The help given by many business leaders and professional associates is gratefully acknowledged; recognition is made in the text for their contributions. Special appreciation is due Professors Myron L. Begeman of the University of Texas, Charles B. Gordy of the University of Michigan, W. F. Spafford of Rensselaer Polytechnic Institute, and H. Barrett Rogers and Franklin G. Moore of Northwestern University for their detailed suggestions and reading of certain chapters. My associates at Northwestern University, Professors Chester Willard, Adolph Langsner, Frank F. Henry, and Joseph W. Towle, have also made valuable suggestions as they have taught the course over the past five years. I am especially appreciative of the help given me by my wife in correcting the manuscript.

WILLIAM R. SPRIEGEL

EVANSTON, ILLINOIS
January, 1947

PREFACE TO THE THIRD EDITION

The fundamentals of management have changed little if any since the Second Edition of this book appeared in 1928. During the past decade, however, the emphasis on managerial technique has shifted considerably. It is to include these external social influences and recent trends in technical details that this revision has been undertaken.

The text is intended primarily for the college student who has had little or no industrial experience, although the essential features of the Second Edition, which has been successfully used in evening classes by hundreds of employed men and women, have been preserved. Extensive use has been made of the illustrations to enable the student to visualize more accurately the techniques and industrial situations described.

There has been no attempt to make an original contribution to the literature on management. Most of the new material of this edition has appeared in some form in management periodicals, has been presented at meetings of the professional societies, or has grown out of the authors' industrial experience. A conscious effort has been made to present what appears to the authors to be a sound philosophy of management, which may be summarized as a balanced relationship between the equities of the consumer, labor, owners of capital, management, and organized society or government. Any deviation from this approach has been a question of interpretation, not intent.

This new edition emphasizes the social and personnel aspects of industrial organization and management. A chapter has been included briefly summarizing some of the governmental influences upon management. Throughout the text the central aim has been to present a unified treatise. The technical sections of Chapters XI, XII, XIII, and XVI are presented as a matter of general information for the student; it is not expected that the average student will master these technical details.

This revision is built on the firm foundation laid by Mr. Lansburgh in his first two editions, and the privilege of using his second edition and accumulated notes is gratefully acknowledged. Professors Leon Bosch Adolph Langsner, and Arthur Bronwell of Northwestern University have made valuable suggestions concerning the arrangement of certain material. Professor Bronwell made a special contribution to Chapter XIII, "Factory Power." Mr. L. B. Cappa and Mr. R. J. Seitz of the Public

Service Company of Northern Illinois made valuable contributions to the treatment of industrial power and light. The representatives of the many industries referred to by name in the body of the text have been especially co-operative in supplying source material.

WILLIAM R. SPRIEGEL

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PREFACE TO THE FIRST EDITION

WITH the confident judgment that in careful analysis of management problems is to be found the hope of industry, this book has been developed. Stress has been placed on general organization problems, not only in the chapters on organization, but throughout the text, with the deep conviction that if a satisfactory structure be developed for any enterprise, all other phases of management are simplified.

With the hope of stressing the fundamentals of sound management, which must be developed prior to granting attention to more spectacular phases, a number of chapters have been devoted to the background of present-day management policies, to organization as an abstract consideration, and too often-unappreciated standardization work. Throughout, the effort has been made to show the relationships of each major portion of the business to the others and the interdependence of the various major departments. Policies and principles of successful management form the background, into which are fitted the devices to carry them into effect, without which no management, however highly conceived, may be successful.

Operations have been treated with the belief that faith must be created in modern business, faith of the management in the employee, and faith of the employee in the management. They have been described with the thought that worthwhile management must be courageous, must be willing to lead, but must be always careful lest unprofitable experiments discourage future attempts to improve management methods.

The examples and illustrations have been chosen from a diverse group of industries in the hope of insuring that good management be looked upon as universally applicable. At the same time they have been chosen from the standpoint of best explaining the problem at hand. Illustrations have been taken from particular plants, wherever practicable; but necessarily, for clarity and to reach fundamentals, applications have at times been made to insure full understanding of the general principles. In the main, the text has been developed from the point of view of the medium-sized plant, but frequent reference has been made to the large and the small enterprise. Such basic principles and policies as have been laid down are applicable everywhere, and only the systems and devices which carry them into effect must be modified as the size of the plant changes.

In brief, this book aims to present a co-ordinated, simple treatment of the problems, the ideals, and the methods of successful industrial management in a way which is at the same time broad and specific, and which aims to indicate the responsibilities of the factory executives to the workers, the stockholders, and the community.

During the preparation of this book, over a period of several years, the constant help and advice of numerous industrial executives has made possible the presentation of much of the material which is included. The author wishes to express especial appreciation of the aid received from Mr. Percy S. Brown, Works Manager of the Corona Typewriter Company; Mr. George Comfort, Works Manager of the Miller Lock Company; Mr. James M. Ketch of the National Lamp Works; and Mr. H. K. Hathaway, Consulting Engineer in Management. Mr. Charles B. Gordy, Assistant Professor of Mechanical Engineering, University of Michigan, and Mr. John S. Keir, Professor of Industrial Economics, Carnegie Institute of Technology, have also rendered criticisms and comments which have materially assisted in developing the text. During the preparation of the book continual constructive comment and criticism, and, indeed suggestions for rearrangement of material, as well as much of the material itself, have been received from the following, who are or have been instructors in the Department of Industry of the Wharton School of Finance and Commerce of the University of Pennsylvania: Messrs. Robert P. Brecht, John W. Carter, Leon Henderson, Victor S. Karabasz, Francis P. O'Hara, Norris M. Perris, Theodore R. Snyder, and Morton S. Whitehill. For reading the completed manuscript and making numerous valuable comments thereon, the author is very grateful to Professor Erwin H. Schell, of the Massachusetts Institute of Technology. He wishes to express his deep appreciation of the aid received from all these sources, to which such features of this text as may be valuable are largely due.

RICHARD H. LANSBURGH.

PHILADELPHIA, PA.
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PART I

INTRODUCTION

CHAPTER 1

THE HISTORICAL BACKGROUND OF INDUSTRIAL MANAGEMENT

Industrial history. The factory system is frequently referred to as the fourth milestone of industrial history, the first three being *domestic production, handicraft production,* and *cottage production.* The factory period, however, is composed of divisions as nearly distinct as the several periods themselves.

Domestic production was production in the household, for the members thereof, from raw materials furnished largely by the household itself. In its present form, found at any time only for a temporary period and only on the very frontiers of civilization, domestic production implies essentially an absence of exchange and the ability of each household to satisfy the wants of its members by its own labor.

Handicraft production was carried on either within or outside the house and was characterized by what is called "custom production." The handicraft producer usually worked for the consumer of his product, the region of the sale tended to be local, and the product of one craftsman might be bartered for that of another, or an actual sale might take place. The development of handicraft production was accompanied by the growth of guilds, or associations of workers in the same trade, banded together to promote their mutual interests. The growth of a particular guild in a town often caused that town to become the center of a certain type of manufacturing, and the guild in time came to control the town government as well as its trade. There was no large class of wage workers under the guild system, but each worker, having passed through his years of apprenticeship, could become a master of the craft. There was no employer or employee class.

The control of guilds over production did not survive up to the opening of the factory era, although, in a larger sense, handicraft production did. The gradual development of capital, the discoveries and explorations of

the fifteenth and sixteenth centuries, and the consequent growth of trade together caused the power of the guilds to decay, partly because of their restrictive regulations, such as the strict limitations which they placed on the number of apprentices. During this period of the guilds the entrepreneur began to make his appearance in industry. The master worker or merchant who had accumulated some capital bought raw material and distributed it to workers, later collecting and distributing the finished product, either directly to consumers or to merchants. In the sixteenth, seventeenth, and early eighteenth century this method prevailed in the manufacture of staple commodities and became the forerunner of the factory system. As a result of this plan the era came to be called the "cottage period" of industry, since so much of the work was done in cottages just outside of towns. The workers still owned the tools of production, but the contact with consumers of their product was made for them by merchants. Many sections of Japan today carry on this type of manufacturing extensively. A similar system prevails in our southern states, where the manufacture of candlewick bedspreads, chairs, and other articles is often carried on at home.

It is estimated that in Germany just before 1800 there were at least twenty establishments, each employing between one hundred and five hundred persons. These factories were essentially an extension or outgrowth of the domestic system of production. They existed side by side with the handicraft system. Specialization of labor took place to a limited extent, yet these establishments should not be thought of in the sense of the modern factory. Had it not been for the Industrial Revolution, it is conceivable that these factories might well have replaced the prevailing handicraft system, thus producing social dislocations similar to those that followed the Industrial Revolution in England.[1]

The factory system. The chief factors bringing about this new scheme of industrial production were four inventions, made in England during the closing years of the eighteenth century, which provided machines for the textile industry. James Hargreaves' spinning jenny, patented in 1770 but in use several years before that date, was the first machine to spin yarn. It was improved upon in 1771 by Richard Arkwright, who invented what he termed a "water frame." In 1779 Samuel Crompton constructed his "mule," so called because its construction embodied features of both earlier inventions. This device increased the potential production of yarn beyond the ability of the weavers to make it into finished fabric. This condition was directly contrary to that prevailing

[1] See Dexter S. Kimball, *Principles of Industrial Organization,* Fifth Edition, McGraw-Hill Book Company, New York, 1939, p. 8.

before the invention of Hargreaves' jenny, when the use of a "fly-shuttle" (practically a hand device) had given weavers a capacity for work that could not be met by the spinners. By this time, however, the invention of textile machinery had gained a fair start, and the need was met in 1785 by the fourth great invention, Edmund Cartwright's power loom. These inventions served, within comparatively few years, to revolutionize the textile industry—the industry which, possibly more than any other, is closely interwoven with human wants and human progress—and to place it on a machine basis. Although it was not until the invention of the steam engine by James Watt and its adaptation to factory work in the closing years of the century that industry broke away from the hampering limitations of the use of water power, the real Industrial Revolution, the change toward the factory system, had begun.

Similar inventions or changes in method took place simultaneously or shortly thereafter in many lines of work, particularly metal-cutting. The slide-rest for accurately guiding cutting tools, the turret, and the combination of these two elements into the automatic lathe by Christopher M. Spencer of Connecticut were the epoch-making improvements in machine-tool construction, and they were all made about this time. It would be difficult to overemphasize the importance of these metal-working tools. They can be and are frequently used in mass production, but they are essentially general-purpose machines in contrast to special-purpose production machines. The machine tools are used in making the production type of machines. Motors, pumps, generators, and special-purpose high-production machines are produced with the precision type of machine tool. Watt, for example, was thoroughly familiar with the principles of his steam engine long before he was able to build a production engine. He was forced to wait more than a decade before a boring machine was devised to turn the cylinder with sufficiently accurate dimensions from the bottom to the top.

Effects of the Industrial Revolution. The effect of the Industrial Revolution was felt almost as quickly in the United States as in England. The first cotton factory of any importance in the United States was established in 1790. The differences between the United States and England lay in the fact that England was primarily an industrial country, whereas there was but little manufacturing in the United States. The immediate effect on the social and economic life of the people in America therefore was less marked, although largely governed by the same influences.

An illustration of the transfer of skill from the worker to the machine is found in furniture manufacture. Under the old régime and even today in the small-scale custom production shop the worker was a cabinet-

maker, one of the aristocrats among skilled workmen. When volume justifies the expense involved, practically all such work as cutting to lengths and shaping is reduced to machine operations, with only the assembling in fixtures done by hand. The product of the present assembly is more uniform than that of the skilled mechanic under the hand-assembly methods. An alert farmer boy or girl can easily learn to make this assembly in a three-day period. The cabinetmaker, on the other hand, served an apprenticeship for four years.

Since the transfer of skill involves, at least temporarily, loss of earning power for the particular workers involved, it is not hard to account for the frequent opposition of workmen to the introduction of new machinery. The skilled worker found himself *degraded* in many cases to the level of unskilled girls and boys, who could operate the new machines. The degrading effect of transferring skill from the worker to the machine was not permanent for the working class as a whole. Large groups of workers were soon needed to produce the machines with which the others worked, and this, together with the general expansion of industry, afforded increasing employment for skilled men. Frequently, however, the individual suffered, as did the skilled weaver, whose place was taken by the automatic loom; the skilled work was largely done by the metal worker, in an entirely different trade. The result was the economic degrading of the displaced skilled worker and an increase in the number of skilled workers required for the manufacture and servicing of the tools and equipment, making a net gain to society as a whole, but a distinct loss to the group displaced. These new machines were operated by the group that formerly comprised the unskilled workers. They now became semiskilled operators, a change which raised their economic status. The decreased cost of the finished product widened the market, thus increasing the total number of units required and making possible a general rise in the standard of living.

Opposition to new machinery was strong even in the early days of the Industrial Revolution. A mob of spinners wrecked the first machine built by Hargreaves. An early American illustration of the opposition of vested interests of workmen to the introduction of new equipment and methods is significant. When the West was first being opened, materials and supplies were transported across the mountains from Virginia and North Carolina into Kentucky by pack trains of horses and mules. This was a slow and expensive method. Soon the trails were widened, and wagon trains began to move westward. The pack-train drivers opposed this method and rolled stones down the mountain sides to destroy the wagon trains and the new roads. The idea has persisted to the present. Congress was influenced by pressure from organized labor to insert a

provision in the Emergency Transportation Act of 1933 to the effect that action taken under this act should not reduce the number of employees below the number employed during May, 1933, after deducting the number removed by death, retirements, or resignations. Opposition to the introduction of new devices may be directed toward machinery which itself increases output or absorbs workers' skill. However, it often has been directed toward devices or management methods which study processes or measure output in order that management may know better how quickly work should be done.

The effects of the transfer of skill were far-reaching and complex. One immediate effect, and one of the most significant, was to separate the worker from the ownership of the tools of industry. No longer was it possible for the apprentice, becoming a craftsman, to be presented by his proud mentor with the implements of his trade. Capital was now required both to build these new tools and to provide power to operate them. The rise of the capitalist class, already begun, was therefore accelerated. The immediate results, particularly in England, of the rapid rise of this newer class in society and the accompanying degradation of the worker are well known. If it had not been the day of the economic doctrine of *laissez faire* and if Britain had not been engaged in a long series of foreign wars, the industrial history of the period might have been different; but it now stands as the historic example of frightful working conditions—child labor to the point of death in childhood, and general inhuman treatment of the worker. It was the natural result of too-rapid transition from one economic era to another.

The factory system in the United States. When the manufactures of the United States began to grow in the second decade of the nineteenth century, the factory system was established, but its social effects were not so severe as in Europe, where different manufacturing conditions were overturned. The factory system in the United States today bears no resemblance to that of 1850 and very little to that of 1900. There have been fairly distinct periods, during which various aspects seem to have been more important than others, but no fine limiting date lines can be set for each period. The three most important divisions have been:

1. The period in which the foundations were laid and the structure was started.
2. The period of great industrial expansion.
3. The period of attention to operating methods.

Early American business. The first period was characterized by small factories, patterned basically along European lines, with relatively narrow markets and organizations dominated by the owner, or capitalist. The growth of a middleman organization and a financial organization to

market the rapidly increasing product of the factories also was characteristic of this period. As a basis for its early growth American manufacture had the transplanting of European industry, almost bodily, to the shores of this country. European workmen, European machinery, frequently European superintendence, and even European raw materials formed the entire groundwork for the establishment of our early manufacturing. The development of the merchant class, which was in existence long before the formation of the manufacturing-capitalist class, quickly progressed. The structure comprising jobber, wholesaler, and retailer, with which we are familiar, grew up. Trade customs came to be established in certain industries, as in branches of the textile industry, whereby all goods were produced primarily for a middleman, who took over all phases of the marketing.

A financial group arose whose business it became to provide the means of carrying on the rapidly increasing transactions between these newly established groups of industrial society. The larger the competitive area over which a product was distributed, the more necessary became the services of the financier; thus his growth to a dominating position in industry followed the increasing development of markets.

Despite this opportunity of personal contact in the early days of American industry, labor troubles were numerous and could hardly be called less violent than those experienced today. They were, however, sporadic and unorganized. Strikes occurred, many being caused by the attempt to abolish in manufacturing the long hours of agriculture. It was many years before the ten-hour day became common. The governing philosophy of modern management had not even caught a foothold in the industry of the time. There were many attempts to form labor organizations, some of which were successful for a time, but there were no national union organizations. Those that were successful were local associations of workmen in specific trades.

Industrial expansion. During the period of the great industrial expansion the United States rose from the position of a novice among nations in manufacturing to the position of the greatest manufacturing nation in the world. Not only was the home market larger because of the unsatisfied wants of a growing population, but also the size of this market was important from a political and geographical standpoint. Business flowed freely, unhampered by tariffs and other barriers, from Maine to California and from Puget Sound to Florida.

The division of labor resulting from the first machine inventions was further increased as manufacturing methods under the factory system developed. With each invention of a machine, division of labor was likely to increase. Increased division of labor made possible further con-

struction of machines to perform the simplified operations creating a reciprocal relationship. Thus the spiral of simplification of operations and machine development continued. The two factors became both cause and effect when looked at from different points of view in the cycle of development of production equipment. Transfer of skill to machines made possible the reduction of manufacturing costs, bringing wider markets that made possible increased production. Increased volume of production encouraged simplification of operations and justified expenditures for further mechanization.

The service rendered industry by improved communications cannot be measured. Without the growth of the railroad map and railway shipping accommodations and service, taking place simultaneously with the development of the telegraph and telephone which made possible the dissemination of news and market information, there could have been no such industrial growth as has occurred.

Watt's invention of the steam engine helped to revolutionize industry, but the development of the dynamo and electric motor created real industrial power. Invention during this second period of American manufacture founded great new industries, filling new wants and creating whole new markets. The use of electricity for power, communication, and light created within the last three-quarters of the century one of the great basic industries. Within the last forty years the successful use of the gasoline engine for transportation purposes has given the United States the automobile industry, one of its truly great enterprises. The beginnings of all these industries, the refinements in manufacturing technique, and the improvement in product which followed and broadened the market for each are all characteristic of the second period in American manufacturing.

Eli Whitney is known to every sixth-grade American schoolboy as the famous inventor of the cotton gin, but few persons know that his greatest contribution to modern industrial practice was the introduction of the manufacture of standardized interchangeable parts. American manufacturing developed so rapidly, under conditions entirely different from those of Europe, that it soon found itself practically free from the bonds of European influence.

The growth of labor unions, organized along present lines of the American Federation of Labor, is another development of this period. The labor unions exist as the crystallization of the labor movements of earlier American industry and of forces in existence since the guilds. The recent growth of the Congress of Industrial Organizations is a further attempt of the labor movement to adjust to corporate large-scale mass production.

The third period. Attention to operating methods. Many companies began to direct attention to economies in production and accurate cost-finding methods that gave them an advantage in the establishment of selling prices. The scientific industrial age began to arise out of the changed conditions. Attention to methods of operation is the outstanding feature of this era. Possible methods of saving through more effective factory operation are considered, thrashed over in executives' meetings, and adopted as a part of plant policy.

The tendency toward the creation of larger enterprises continued up to the beginning of the depression of 1932.[2] At least, there was a definite tendency to create "interests," which controlled many enterprises from a central location. The giant corporation, owned by hundreds or thousands of investors, had become common. Such an organization implies control of many plants through operating or managing representatives of the owners, financial representatives, sales representatives, and production representatives. In this organization lies an additional reason for attention to operating methods.

Ownership and management. The stockholders of a corporation meet in person or by proxy once a year to pass on certain policies referred to them by the board of directors or originated by the stockholders at a regular meeting and also to elect a board of directors to represent them in the active conduct of the enterprise. During the past twenty years the ownership of the voting stock of our large corporations has undergone a marked change. Stocks have become widely distributed. In 1945 the General Motors Corporation, according to its annual report, had 425,657 individual stockholders. It is evident that even one per cent of them would find it difficult to voice their desires at an annual meeting. As a matter of general practice most stockholders give proxies to some member of the top management, thus tending to perpetuate a given management in power. This trend in administrative and managerial structure is an outgrowth of the third period in the development of American industry. It has brought into existence the professional manager with pressure from the outside for dividends. The real owners of our industries are relatively silent in their management and administration. This situation raises new problems and makes it imperative that there be a profession of management that is truly scientific, with deep-rooted traditions of social justice to all.

[2] For the past several years (1935–1946) there has been much discussion in managerial and economic circles concerning the optimum size of an enterprise for maximum efficiency. This discussion has also entered the field of political economy. In individual states certain punitive tax laws directed at chain stores have been passed. Just where this movement will end no one can accurately predict.

The effects of World Wars I (1914–1918) and II (1939–1945) on management. Under the influence of patriotism during World War I both managerial attitudes and labor cooperation underwent a change that, in fact, was revolutionary in comparison to performance before this period. Habits formed in war carried over into peacetime operations. It would be unusual indeed to find an industry making war supplies that did not have its peacetime methods changed through being forced out of the well-worn ruts of years of routine operation.

There came into the concepts of both employer and employee an increasing sense of the importance of the individual worker to industry. Whereas before the war the emphasis in managerial matters was placed largely on the physical aspects of management, such as plant, equipment, and materials, after World War I attention was directed equally to the human element. A fundamental change in attitude on the part of the directors of industry developed.

During the third decade of this century rapid strides were made in manufacturing processes, procedures, and techniques. Industry expanded; mass production came into its own. The general standard of living rose markedly. The total passenger-car registration rose from 6,771,074 in 1919 to 23,121,589 in 1929. Although passenger-automobile registration is not the sole index of the standard of living, it is at least an important factor in measuring this standard.

Management techniques that were only discussed before World War I were tried out during the war effort and became commonplace in the next decade. During and following the depression that began in 1932 the companies that followed scientific principles of management fared better than those that followed tradition or custom.

World War II provided an outstanding opportunity to try out scientific principles of management on a large scale. Hundreds of new plants were built which required (1) organization structure, (2) training of executives, supervisors, and workers, (3) plant layout, material handling, and special-purpose equipment, (4) production control, (5) material control and storage, (6) purchasing, (7) packaging and shipping, (8) motion and time study, and (9) personnel management and administration. Tremendous strides were made in all these fields. Very few strictly new developments were made in the field of management, but established principles were given a wide field for tryout and use. More people, both workers and management, became conscious of the possibilities of scientific management than ever before. Unionization of workers increased tremendously from 1935 until 1946, and management strove to develop procedures and techniques to make its relationship with unions a success. At this time unions are no longer weak; in their collective strength they

are frequently stronger than the individual employer or employer group. In all probability the next big problem to be solved is the protection of public interest from the results of unnecessary industrial strife. It is to be hoped that real collective bargaining will resolve these conflicts without governmental domination. During World War II it was clearly demonstrated that real collective bargaining is not engaged in when either side thinks that it can appeal to the government and thereby get more than it can by settling its problems at the bargaining table.

Scientific management has been able to solve practically every problem but labor relations. Nevertheless the scientific approach to this problem promises hope. Such an approach to labor relations involves an area in which little work as yet has been done. The logics of sentiments control human relations more than the logics of efficiency.[3] Although scientific methodology can be applied to this area of management also, the technique is not so simple, and a longer time is required to see the results than is necessary in material things.

The financial institution and industrial management. For many years the financial institutions engaged in granting credit to manufacturing establishments were accustomed to look primarily at the physical aspect of the plant. The balance sheet of the factory, as expressed in terms of machinery, plant and structures, raw material, and finished product, plus accounts owed or receivable, was the basis of extension of credit, subject, of course, to such influences as good will or the individual reputation of the managing executives. Good management was presupposed, and yet poor management could waste the assets of the factory to such an extent that the figures on the balance sheet might be changed immeasurably before the financial institution could clear itself.

Today financial institutions appreciate industrial *administration* and *management* as vital business factors. Although they still require the physical balance sheet to meet certain standards of safety before advancing money for operations, those banks which give industry the most mature consideration go beyond the physical balance sheet in estimating the worth of the institution. Many banks have on their staffs specialists whose duty it is to survey the administrative policies and management of a business as a supplement to balance-sheet information. Certain consulting companies make a specialty of evaluating the management or executive personnel of industrial plants for bankers.

Definitions. The terms *administration* and *management*, as vital factors in business, have been used but not yet defined. Unfortunately the two

[3] See F. J. Roethlisberger and William J. Dickson, *Management and the Worker*, Harvard University Press, Cambridge, 1940, Chapter XXIV, for an excellent discussion of this subject.

terms have not as yet received universal acceptance in their specialized use. Some authors have employed them interchangeably. Management is sometimes used as the broader term to include all the elements in the control of business activities, the correlation of the details of operation of an enterprise, so that they will work as a harmonious whole toward the desired goal. On the other hand, the substitution of *administration* for *management* in the foregoing sentence will conform to the usage of other writers. This is a regrettable situation.

In one sense, management refers to the executive *personnel* of an enterprise and is frequently used with special reference to the major executives largely responsible for policy formation and the determination of the major objectives. Such phrases as "top management" and "lower levels of management," when referring to the individuals who discharge the respective administrative or executive functions, are quite generally used regardless of the special interpretation given the words administration and management when used in their functional sense. This practice is satisfactory when the context clearly shows that the reference is to executive personnel.

Administration is that function of an enterprise which concerns itself with the over-all determination of policies and major objectives. Administration sets forth the general purpose of the enterprise, establishes its major policies, formulates the general plan of procedures, inaugurates the broad program, and approves the specific major projects that fall within the general program. It should not be inferred that two sets of personnel are required to discharge the administrative and the managerial functions. There is usually a distinct overlapping of individuals in these respective spheres. In a large institution the president may devote a great part of his time to the broader administrative responsibilities; on the other hand, he is most certainly required to participate to at least a limited extent in executing these policies. It is highly probable that combining these two functions in the same person has contributed to the confusion in the use of the terms. The farther down the organization one goes, the greater is the shifting from responsibility of policy determining to execution (see Fig. 1.1).

Management is that function of an enterprise which concerns itself with the direction and control of the various activities so that the parts will be synchronized and thus work together to attain the objectives established by the administrative authorities. Management is essentially an executive function; it deals particularly with the active direction of the human effort. Administration determines the broad objectives and establishes the major program. Management takes the broad plans laid down by administration and follows through the details to the ultimate

solution. Administration is largely determinative, whereas management is essentially executive. The major responsibilities of the executives below the "top management" are managerial. It is true that many of the minor executives in a limited sphere determine policies within the groundwork established for the organization as a whole. When this happens, these executives are performing administrative functions. The major function of the minor executive is not to formulate policies but

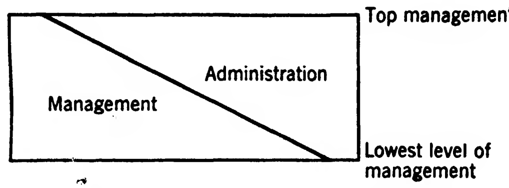


FIG. 1.1. Chart illustrating the division of managerial and administrative functions between top management and the lowest level of management.

rather to interpret them and to direct the activities of his particular unit in conformity with the objectives of the organization.[4]

Business objectives. The executives of a business organization nearly always have very definite objectives in mind when the enterprise is first created. The nature of the enterprise may change and the structural organization undergo many adjustments, but at least one of the original goals will remain, namely, to make invested capital and executive effort productive. The popular way to express this idea is to say that business is conducted for profit. If the term "profit" is used in its popular sense, there is probably no objection to this statement.[5] Owners of capital have a right to expect a reasonable return on their capital when they place it in the hands of others for use, as they do in our corporate structures, or when they personally supervise it in a single proprietorship. The enterprise that does not earn a fair return on its capital faces ultimate disaster. (It is not necessary to go into a detailed discussion of what is a fair return. The Supreme Court has placed it in the neighborhood of six per cent in the case of certain utilities.) When an enterprise earns

[4] See E. H. Anderson and G. T. Schwenning, *The Science of Production Organization,* John Wiley and Sons, New York, 1938, pp. 9–28, for a detailed discussion of the various usages of *administration* and *management* by different authors.

[5] The economist thinks of profit as the residual income after having paid rent for land, interest on capital used, both owned and borrowed, and wages to labor and the executives. Profits, if any, are available to the owners of the enterprise, the common stockholders of a corporation, the members of a partnership, or to the individual if he is the sole proprietor. In an accounting sense, profits represent the excess of income over all expenses. Dividends on stock are not considered an expense.

less than what investors deem a fair return, it cannot secure needed capital for expansion. Other industries in a more favorable situation will be able to make improvements and expand, thus putting the first one at a still greater disadvantage. In the long run the business that does not earn sufficient return on its invested capital to command additional funds when needed will be forced to close its doors, thus depriving its employees of a source of employment.

In many instances the science of business has reached the stage where its practitioners are professional men. One of the distinguishing characteristics of professional men is a highly developed code of ethics that includes social objectives. A large number of trade associations and other groups of business men have adopted codes of business ethics. It is fully recognized that these codes are not always adhered to, but neither are other professional codes, social codes, or even religious codes. The business man who makes a financial success of his enterprise while operating within the generally accepted codes of business ethics or even on a higher level, if possible, makes a real contribution to the community welfare. Long-run prosperity in business brings success not only to the owners of the business in the sense of proprietary risk-bearers but also to all persons who supply funds and materials, major and minor executives, workers, auxiliary enterprises, and the operating community. In a very realistic sense a successful business becomes a cooperative enterprise carried on within the limitations of our capitalistic system of private responsibility and initiative. Profit motives not only are entirely compatible with social objectives but also have thus far proved the strongest incentives to attaining these objectives.

The field of business administration and management. The general field of business administration and management is made up of three broad subdivisions:

1. The establishment of major policies.
2. The planning for and establishment of an organization to carry out these policies.
3. The operation of the enterprise through this organization. As business conditions change, fundamental changes are needed in each of these fields. If a plant does not make changes from time to time as needed, it sometimes becomes necessary to engage in extensive reorganization, which, because of its spectacular aspects, may come to be looked upon wrongly as the main field of the science of management. The best-advertised managerial effort has been reorganization, because it is spectacular.

Managerial and administrative responsibilities and duties call for the utilization of different types of genius, which are not always found in the same man. To establish policies and to plan for an effective organization require mainly creative ability, although this must be coupled with some

power to visualize methods of executing the plans that are devised. To operate a plant in accordance with the policies which have been laid down requires mainly executive ability. The manager who has this gift, together with the ability to create new policies, possesses the characteristics needed by top management.

The objective behind any serious attempt to analyze the factors in industrial management is to study those administrative and managerial policies that have been most effective, to understand the physical phases of production, and to discover the proper balance among the managerial, physical, and employee relationships. In order to fulfill this aim, three steps are necessary: (1) to determine the policies and principles of effective administration and management; (2) to see how they have been applied successfully; and, most important of all, (3) to develop a scientific state of mind toward business problems.

CHAPTER 2

THE MANAGEMENT MOVEMENT

The background of the management movement. The closing decades of the nineteenth century and the first two decades of the twentieth century may aptly be called the period of the captains of industry. These men were founders and builders of great industrial empires; practically all of them were men of vision and dominant personalities. They were pioneers in a new country and in new fields in a growing country. The philosophy of *laissez faire* dominated their activities. This period produced John D. Rockefeller, Sr., the moving spirit in the oil industry; James J. Hill, the railroad builder; John Patterson, who provided the cash registers for the new industrial era; Henry Ford and the Dodge brothers, Horace and John, founders of automobile industries bearing their names; Harvey Firestone and F. A. Seiberling, two dominant figures in the rubber industry; Marshall Field and John Wanamaker, who revolutionized certain aspects of retailing; Thomas Edison and the Wright brothers, great inventors who laid foundations on which others have built huge industries; and many other strong individualists whose influence will be felt long after their names are no longer familiar to the school children in America.

These strong men defied custom and created when others thought the task was impossible. Their beginnings were humble, such as the bicycle shop of the Wrights and the small machine shop of the Dodges, yet most of them lived to see their works prosper to an extent little dreamed of, even by them, in their early efforts. In a very real sense they made the period and the environment made them—a reciprocal relationship, the one influencing the other. They grew with their enterprises. They possessed an intimate, detailed knowledge of each phase of their undertakings. They were leaders by right of natural and acquired abilities and, in a few instances, great fortunes. As they grew, these men carried enormous personal loads and responsibilities. They developed the faculty for ease and speed of decision. This capacity was fostered by complete mastery of technical details and the assumption of responsibility early in life. With the passing of the founders and the dividing of their responsibilities among others, additional attention had to be focused upon organization and managerial methods.

Fundamental factors in the industrial situation would have caused the management movement in some form to have come about within a period of perhaps a quarter of a century. Of that we can be reasonably certain. The exact form of the movement and its starting place were determined, however, by the life work of one great man. Frederick W. Taylor, seeing around him the need for the development of management, began the intensive study of corrective measures which finally led to the development of the science of management, of which he is the recognized founder.

Frederick W. Taylor. Between 1880 and 1890 Frederick W. Taylor laid the foundation for modern scientific industrial management, not only in the United States but throughout the world. No other man has ever lived whose individual work so largely influenced the operation of so many plants in so many and diversified industries as did that of Frederick W. Taylor. His first work was small in itself and finally was largely voided by opposing factions. His influence, though not dormant, was both consciously and unconsciously disregarded for twenty years, and yet, in the development of management methods, it has been greater than that of any other single man.

Taylor was himself strongly influenced when still comparatively young by knowledge of the work of Henry R. Towne, then president of the Yale and Towne Manufacturing Company, who began the application of new management methods as early as 1870 in the plant of that company. It was probably the example of Towne that caused Taylor to direct his efforts to the organized study of management as a science and a profession. Although Towne may have been the pioneer, Taylor was the great leader of the movement. At the time of Taylor's death, Towne himself referred to him as "one of the world's discoverers and creative leaders" and as the "creator of a new science."

Another personality that greatly influenced the early work and entire philosophy of Mr. Taylor was his chief, William Sellers, one of America's greatest engineers, who possessed a keen understanding of his young assistant's enthusiasm and a profound respect for research. Taylor did not have to struggle for permission to make his early experiments. Sellers encouraged him in his efforts and made available to him equipment suitable for the researches. The keen analytical ability of Carl Barth, one of Taylor's assistants at the Bethlehem Steel Company, aided him greatly in the refinement of techniques and in the use of mathematical tables and processes. Others also influenced Taylor's growth and work, but he remained the guiding genius and motivating force of the scientific management movement. Taylor occupies the same position in regard to the science of industrial management that Darwin does to the modern ap-

proach to the pure sciences. Taylor introduced Darwin's techniques to industry.

Early steps of Taylor. In 1882, after transferring from the offices to the shops of the Midvale Steel Company in Philadelphia, Taylor was promoted to machine-shop foreman in the Midvale plant. During his previous experience as a workman Taylor had been constantly impressed by the failure of many of his fellow-workers to produce more than a third of a good day's work. Wages had been paid on a piece-work basis established in terms of past experience, and the men were afraid to let the management know how much work they could really do for fear that the rates would be cut. When Taylor became foreman, he determined to work out some system of management whereby the interests of the management and of the men might be made as nearly as possible the same.

Taylor was convinced that management lacked knowledge of what actually should constitute a day's work. How could a man be held accountable for his full duty when the management had no idea of the man's capacity? It was with this thought as a foundation that most of his writings, researches, and influence over other men was built. He found that management did not really manage and that its attitude toward its responsibilities in this direction must be changed entirely before the workman could be expected to change his attitude toward his work. Taylor felt that the management was asking the worker to do its work as well as his own. His efforts to secure information at Midvale concerning ways in which management might really manage enabled him to develop what he termed the "duties of management," which guided him and many others along newer industrial paths. From time to time the phraseology of these duties was changed by Taylor, but their substance was as follows: [1]

1. The development of a science for each element of a man's work, thereby replacing the old rule-of-thumb method.
2. The selection of the best worker for each particular task and then training, teaching, and developing the workman, in place of the old practice of allowing the worker to select his own task and train himself as best he could.
3. The development of hearty cooperation between the management and the men in carrying on the activities in accordance with the principles of the developed science.
4. The division of the work in almost equal shares between the management and the workers, each department taking over the work for which it is better fitted, instead of the former condition in which most of the work and the greater part of the responsibility were thrown on the men.

Taylor remained at Midvale until 1890. While there he also carried on early experiments in the development of high-speed steel. His dis-

[1] F. W. Taylor, *Principles of Scientific Management,* Harper and Brothers, New York, 1919, p. 36.

covery of this product, in which he was associated with Maunsel White, ranks as an achievement equal to the founding of the modern management movement. The work which he did on high-speed steels was, in fact, an outgrowth of his attempts to find the right way to do jobs. When Taylor left Midvale, it was largely due to factional differences within the organization, and this situation naturally led to the undoing of much that he had accomplished. Nevertheless, even today many of the practices in the machine shops of this plant can be traced back to the time when Taylor was first working there with management methods.

For several years Taylor did not have an opportunity to carry on, upon a large scale, the work that he had begun at Midvale. Although engaged in a number of undertakings in which he aimed to improve managerial methods—several being largely concerned with improvements in cost accounting—there was no one great work carried on in one plant.

Beginning in 1898, he worked at the Bethlehem Steel Company for three years. With the aid of a large and competent force of assistants he reorganized the management and methods of two of the larger machine shops and the foundry and at the same time completed the development of his metal-cutting experiments. It was at Bethlehem that interesting studies in pig-iron handling and shoveling were made, which since have become classic in the field of management. One of the most important of the wage-payment systems was also developed during this time.

After Taylor had been at the Bethlehem Steel Company for about three years, there was a change in the directorate and executive management of the company. The group which came in was unfamiliar with the methods pursued by Taylor and his staff and apparently antagonistic to them. Taylor and his associates left. This withdrawal was followed by changes in method by the new management, and since this development so closely followed the upheaval at Midvale, it cast a shadow on Taylor's work which took some years to live down. This accounts for the slow development of his ideas during the immediately succeeding years. Among the more important plants in which Taylor or his direct associates worked in this period were the Tabor Manufacturing Company and the Link-Belt Company of Philadelphia and the United States Arsenal at Watertown, Massachusetts.

The Bethlehem Steel Company illustration of handling pig iron. Probably the best method of portraying the careful techniques used by Taylor in his work is to use his own words in describing the timing of the operation in loading pig iron.

> This was done by timing with a stop watch a first-class man while he was working fast. The best way to do this, in fact almost the only way in which

the timing can be done with certainty, is to divide the man's work into its elements and time each element separately. For example, in the case of a man loading pig-iron onto a car, the elements should be: (*a*) picking up the pig from the ground or pile (time in hundredths of a minute); (*b*) walking with it on a level (time per foot walked); (*c*) walking with it up an incline to car (time per foot walked); (*d*) throwing the pig down (time in hundredths of a minute), or laying it on a pile (time in hundredths of a minute), (*e*) walking back empty to get a load (time per foot walked).

In case of important elements which were to enter into a number of rates, a large number of observations were taken when practicable on different first-class men, and at different times, and they were averaged.

The most difficult elements to time and decide upon in this, as in most cases, are the percentage of the day required for rest, and the time to allow for accidental or unavoidable delays.

In the case of the yard labor at Bethlehem, each class of work was studied as above, each element being timed separately, and, in addition, a record was kept in many cases of the total amount of work done by the man in a day. The record of the gross work of the man (who is being timed) is, in most cases, not necessary after the observer is skilled in his work. As the Bethlehem time observer was new to this work, the gross time was useful in checking his detailed observations and so gradually educating him and giving him confidence in the new methods.

The writer had so many other duties that his personal help was confined to teaching the proper methods and approving the details of the various changes which were in all cases outlined in written reports before being carried out.

As soon as a careful study had been made of the time elements entering into one class of work, a single first-class workman was picked out and started on ordinary piece work on this job. His tasks required him to do between *three and one-half* and *four times* as much work in a day as had been done in the past on an average.

Between twelve and thirteen tons of pig-iron per man had been carried from a pile on the ground, up an inclined plank, and loaded on to a gondola car by the average pig-iron handler while working by the day. The men in doing this work had worked in gangs of from five to twenty men.

The man selected from one of these gangs to make the first start under the writers' system was called upon to load on piece work from forty-five to forty-eight tons (2,240 lbs. each) every day.

He regarded this task as an entirely fair one, and earned on an average from the start $1.85 per day, which was 60 per cent more than he had been paid by the day rate. This man happened to be considerably lighter than the average good workman at this class of work. He weighed about 130 pounds. He proved, however, to be especially well suited to this job, and was kept at it steadily throughout the time that the writer was in Bethlehem, and some years later was still at the same work.

Being the first piece work started in the works, it excited considerable opposition both on the part of the workmen and of several of the leading men in

the town, their opposition being based mainly on the old fallacy that if piece work proved successful a great many men would be thrown out of work, and that thereby not only the workmen but the whole town would suffer.

One after another of the new men who were started singly on this job were either persuaded or intimidated into giving it up. In many cases they were given other work by those interested in preventing piece work, at wages higher than the ruling rates. In the meantime, however, the first man who started on the work earned steadily $1.85 per day, and this object lesson gradually wore out the concerted opposition, which ceased rather suddenly after about two months. From this time on there was no difficulty in getting plenty of good men who were anxious to start on piece work, and the difficulty lay in making with sufficient rapidity the accurate time study of the elementary operations or "unit times" which forms the foundation of this kind of piece work.

Throughout the introduction of piece work when after a thorough time study, a new section of work was started, one man only was put on each new job, and not more than one man was allowed to work at it until he had demonstrated that the task set was a fair one by earning an average of $1.85 per day. After a few sections of the work had been started in this way, the complaint on the part of the better workmen was that they were not allowed to go on to piece work fast enough.

It required about two years to transfer practically all of the yard labor from day to piece work. And the larger part of the transfer was made during the last six months of this time.

As stated above, the greater part of the time was taken up in studying "unit times," and this time study was greatly delayed by having successively the two leading men who had been trained to the work leave because they were offered much larger salaries elsewhere. The study of "unit times" for the yard labor took practically the time of two trained men for two years. Throughout this time the day and piece workers were under entirely separate and distinct management. The original foremen continued to manage the day work, and day and piece workers were never allowed to work together. Gradually the day work gang was diminished and the piece workers were increased as one section of work after another was transformed from the former to the latter.[2]

Taylor's later life. Shortly after the beginning of the twentieth century Taylor withdrew from actively installing management methods and began to philosophize and generalize on his experiences. The far-reaching significance of his principles and method became clear to him, and he began the task of transmitting them to others through writings and addresses. His writings of this period have become the very foundation of modern-management literature. The first and best known is *Shop Management*. This book was first published in 1903 under the auspices of the American Society of Mechanical Engineers, having been

[2] F. W. Taylor, *Shop Management*, Harper and Brothers, pp. 48–52.

read at a meeting of the society in June of that year. In December, 1906. Taylor presented as his presidential address to the same society his other masterpiece, *The Art of Cutting Metals*. From that time until his death on March 21, 1915, he devoted himself almost completely to the task of spreading the gospel of scientific management.

After Taylor gave up the active practice of management installation, a number of his direct followers quickly appeared to carry on his active work. These men became known as the Taylor School in management work, because their close association with the leader of the movement caused them to be guided in their work largely by Taylor's own methods. At the same time the influence of Taylor was guiding other men in distant parts of the United States and even in other countries along paths which led to the same goal. In the hope of finding methods that would avoid the problems that occasionally arose in connection with some of Taylor's detail methods, these men developed other procedures which frequently seemed to differ from those of Taylor. Although the devices differed, the principles, if the work was sound, were Taylor's. In fact, even when opposition to Taylor's work still existed, manufacturing executives who thought themselves opposed to Taylor were, in fact, following frequently the very lines of thought that were primarily his. This situation was due to the wide diffusion of Taylor's principles through his disciples and also to the fact that his principles were basically sound for the era into which manufacturing was entering.

Taylor's position in the management field is that of the first thorough explorer. His researches, because of his personal ability, carried him further than might have been expected. Unfortunately, he was not a salesman, as far as his own work was concerned. Those close to him were always able to see the careful thought and study behind his conclusions, but others did not have this advantage.

The public and even a large percentage of factory executives, not excluding those in the metal trades, did not have their attention focused on scientific management by any of the early work of Taylor or his followers.

Taylor himself was disappointed at the reception of his first paper, *A Piece Rate System,* read before the Society of Mechanical Engineers in 1895. He had used a popular title as a medium of getting fundamental managerial principles before his associates. They remembered the vehicle but forgot its fundamental concepts. He tried to correct this situation in his later paper, *Shop Management,* read before the same society in 1903. A few of his audience grasped his over-all concept of scientific management, but most of them focused their attention on details, entirely overlooking his basic plea. Although there had been a constant improvement in management methods and many men were already making manage-

ment service a life work, in 1910 scientific management had not captured the fancy of any large portion of the industrial world.

Taylor's wage theory. As has been intimated, the current interest of engineering societies during the more formative years of Taylor's industrial life was centered on segments of managerial activities rather than in "scientific management" as an entity. Wage-payment plans held the stage for a season. Taylor evolved a system which was a part of his broader program of managerial controls. His first premise was that no wage plan was equitable either to men or to management unless it was based upon accurate knowledge. He contended that in most instances this knowledge was lacking but that it was determinable, as illustrated by the description of timing pig-iron handling. On the assumption that accurate standard tasks have been established, the essence of Taylor's differential wage is as follows:

1. The maintenance of such conditions that the daily task can be accomplished by the worker.
2. High pay for tasks successfully completed.
3. Low pay for failure to attain the required task.

His major emphasis was upon carefully establishing tasks and making their attainment possible. This placed a heavy responsibility upon the executive group, for workers would not long remain silent when they received low pay because of the shortcomings of their bosses. Taylor's program provided a high reward as an incentive for the worker to accomplish the established task.

Taylor's attitude toward unionism. Taylor referred to trade unions on many occasions, and, contrary to an erroneous opinion, he was not opposed to organized labor as such. In Taylor's opinion scientific management removed the need for organized labor, but he stated, "There is no reason on earth why there should not be collective bargaining, under scientific management just as under the older type, if the men want it." [3] Under many situations prevailing in industry Taylor specifically sanctioned combinations of workmen as a matter of necessity to protect their interests. "When employers herd their men together in classes, pay all of each class the same wages, and offer none of them any inducements to work harder or do better than the average," he said, "the only remedy for the men lies in combination; and frequently the only possible answer to encroachments on the part of their employers is a strike." [4] He se-

[3] "Hearings before Special Committee of the House of Representatives to Investigate the Taylor and Other Systems of Shop Management," Washington, 1912, p. 1444.

[4] Frederick W. Taylor, *Shop Management,* Harper and Brothers, New York, 1919, p. 186.

verely criticized certain practices of organized labor, such as restriction of output, the use of force or intimidation, and the oppression of non-union workmen. On the other hand, he commended wise union leadership that promotes cooperation, naming particularly the Brotherhood of Locomotive Engineers as an example.[5] To summarize, it may be said that Taylor believed that scientific management removed the necessity for labor organizations but that there was no logical reason why men should not affiliate with unions of their own choice under scientific management.[6]

The management movement and the Middle West. In the general growth of the management movement, the leadership that had been Philadelphia's was largely lost. Sections of the country which were less conservative in management method adopted the new ideas more readily and in larger proportions than did eastern sections. New businesses which were developing, such as the automobile and allied industries, had a made-to-measure opportunity to develop management method along with manufacturing technique. These industries were located mainly in the Middle West. This section grasped the opportunity of increasing effectiveness of operation that was offered by management method and gradually developed, in many scattered localities, procedures of operation which, although built on the same firm foundations as those that served the early leaders of the management movement, were constructed along newer and bolder lines. The best-known illustration of this work is the Ford Motor Company, whose demonstration of the economies incident to standardized operation, continuous assembly, and newer wage-payment concepts has profoundly influenced the whole of American industry.

The management consultant. Management has become the profession of the plant executive, not merely the profession of the few who specialize in it. Those who do specialize in management fit into the scheme as specialist cooperators with the managing executives of industry. The management engineer fills a very real niche in the halls of industry. He is a combined product of the age of scientific management and the age of specialization in industry. He specializes in management and administration and sells his services, either along general or special lines, to the executive in charge of the enterprise. He brings to one plant the knowledge of many. He helps to rehabilitate run-down concerns by bringing in the refreshing stimulus of an outside point of view, and he also renders a special service to the prosperous, well-managed enterprise.

Relatively few small or medium-sized industrial enterprises are organized in such a way as to have a broadly trained group of men whose

[5] *Ibid.*, p. 188.

[6] See Edward Eyre Hunt, *Scientific Management since Taylor*, McGraw-Hill Book Company, New York, 1924, p. 52.

sole duty is to collect facts, appraise the over-all situation both within and without the enterprise, and give impartial recommendations. Many executives, even the group largely responsible for policy determination, are tied down with managerial responsibilities. Few of them have the time, the temperament, or the capacity for objectivity necessary to appraise the results of their own handiwork. In enterprises both large and small pressing problems arise from time to time that require very special treatment. In the larger organization it is possible to set up a special department to do the required work; in some of them such a department exists. Seldom indeed are men with adequate training found within a given organization when it is desired to establish such a department; the personnel is usually recruited mainly from the outside. As a result much time is required both to secure the men and to weld them into a functioning unit. Where time is an important element, it is nearly always preferable to secure the services of an established professional consulting firm rather than to try to establish such a department within the firm. In those firms already having distinct departments established for making surveys and formulating policies, it is seldom indeed that these departments have the wide contacts and thorough knowledge of prevailing practices in similar situations that the outside professional organization possesses. Frequently the regular executive lacks the time to make intensive studies and analyses because of the interruptions of routine affairs. Moreover, the professional consultant is practically free from the suspicion of prejudice or favoritism frequently encountered when recommendations are presented by interested parties. He is in a position to state plainly from without certain truths that could not safely be expressed by persons within the organization. The qualified consultant has acquired techniques of working quietly and effectively within an organization without disturbing the routine functioning of the enterprise.

The management consultant is not the only expert who is used by industry. He came in after the certified public accountant, who occupies practically the same position in the accounting field as the management consultant in the managerial field, yet his advent is not so recent as that of the income-tax expert, whose duties frequently partake more of a legal than an accounting nature. As a recent development, the various phases of industrial consulting have become rather specialized. For instance, one type of industrial consultant advises only concerning the construction of a new building or the remodeling of an old one, specializing in such matters as the type of building construction, fire hazard, or the routing of the product through the factory. Even more recently, the consultant who deals only with personnel administration has found a place in the industrial scene. The labor-relations counselor is a specialist

in one phase of personnel administration, namely union-management relations.

The management consultant rendered an invaluable service in the new plants built to meet the requirements of the World War II effort. Every phase of management—building the plant, making the plant layout, training the executives and workers, constructing the organization structure needed for operations, and guiding the enterprise through the early days of operation—was aided by the management consultant. Managerial knowledge was thus multiplied many times through the aid of the professional management consultant. Both the Army and the Navy used the management consultant to streamline operating procedures in Washington as well as in the field. A national authority applied the principles of motion economy to certain phases of operations in the Pacific theater. Another specialist studied the submarine and improved the arrangement of the control mechanisms. Thus the principles of scientific management were used in the greatest national effort to date.

Special management departments within the plant. Two departments within a modern plant are extensions of the early efforts at scientific management, namely, the methods department and the industrial engineering department. The industrial engineer studies methods, procedures, and processes to increase their efficiency. Frequently the motion- and time-study department is under the direction of the industrial engineer. The methods department takes the blueprints from the product engineer, specifies the routing of the product through production, and designs tools, jigs, and fixtures for use in actual operations. At times the industrial engineer makes studies of organization structure as well as procedure. This is not a common practice, however, since relatively few engineers are specialists in organization. In recent years a new department known as the *organization department* has been created, which specializes in establishing organization structure, maintaining balance in the organization, developing an organization manual, reviewing the performance of the respective departments, and maintaining control through the budget. Many of these activities belong in the personnel department and the others in the comptroller's division. There may be an advantage in setting up the organization department as a separate unit when the personnel director is not capable enough to handle this function. It is better organization, however, to secure a personnel director of vice-presidential caliber who can direct the activities of the organization department as a section in the personnel division rather than to have another department reporting to the president or other top executive. These groups in industry have an important part in the progress that the scientific-management

movement is making, for they have the advantage of daily contact with the management problems with which they deal. The consultant is of service even to them, for he brings the experience of many organizations to help in the solution of the problems that confront them.

The future of the management movement. The management movement is behind the scientific method of attack on problems of business, but it no longer upholds any particular device or set of devices as the only scientific method of attack. Staff departments which once seemed inseparably attached to any form of scientific management have been eliminated by some companies in times of financial stress, yet the scientific-management method has been used by these companies in attacking their problems. The true scientific approach to the question is the study of the service that such a department may render or has rendered, as compared to the cost of its operation. This same comparison, of course, must be expanded to include alternative departments if any other than the one under consideration might do the desired work.

Organized labor has appropriated many of the techniques and philosophies of scientific management. The International Ladies Garment Workers' Union maintains an industrial engineering department that represents the union in establishing standards. "We urge upon management the elimination of waste in production in order that selling prices may be lower and wages higher." This statement was contained in a resolution adopted at the convention of the American Federation of Labor in 1925. In the words of President William Green of the American Federation of Labor labor realizes ". . . that its future welfare and best interests are interdependent with industrial progress and business prosperity, and we are placing a distinct emphasis on proposals that will lead to opportunities for co-operation."

A statement of policy by the Steel Workers' Organizing Committee, C.I.O., shows the attitude of cooperation on the part of a section of labor toward certain aspects of scientific management.

1. The union agrees to cooperate with the management in order to reduce costs, enlarge sales, improve quality, and in general advance the interests of the industry.

2. The management agrees to share equitably with the union any benefits so obtained, in the form of increased employment, better working conditions, increased wages, or decreased hours.

3. Nobody is to lose his job as a result of any improvement that is installed. If ways are discovered to do more work with less labor, they are to be adopted naturally and then only with the consent of the union. They must be installed in such a way that no discharges are necessary—for instance, at a time when sales and output are increasing.

4. The research must be truly joint in every respect. All facts and plans are to be revealed to the union committee, and its understanding and consent must be obtained at every step.[7]

Such expressions coming from both the A. F. of L. and the C.I.O. should mean much for the scientific-management movement. It will be recalled that organized labor was formerly avowedly opposed to studies to promote efficiency and reduce waste in production.[8]

A number of other factors are combining to insure steady progress for the management movement. Among them are the growth of societies[9] whose membership consists largely of plant executives and whose interests lie entirely with management problems, the increasing output of literature, both periodicals and books, on scientific-management subjects, and the attention being devoted by the next generation of factory managers, now in educational institutions, to management as a study.

Just as the growth of scientific education in colleges during the last fifty years has aided in revolutionizing American industry, so the expansion of managerial education is likely to aid the management movement in further revolutionizing it. In 1915 there were not five courses in management given in American universities. Today practically every business and engineering school in the United States offers such courses. Although this extremely rapid growth of management instruction has been a response to the demand from industry, in many cases it has led the demand and has, through its graduates, called the attention of industry to the strides that have been made in management in other sections of the United States. This development is one of the most important in management in recent years, particularly when industry and the colleges have cooperated in management education, for in practically every case where this has occurred, the combination of practical and theoretical instruction has resulted in distinct advances in the science of management.

Some schools cooperate with business so that the student goes to school three months and works for three months. In this manner the student is enabled to combine practical experience with a study of basic principles.

[7] The Steel Workers' Organizing Committee, "Production Problems," *Publication No. 2*, 1938.

[8] See "Hearings before Special Committee of the House of Representatives to Investigate the Taylor and Other Systems of Shop Management," 1912.

[9] Such societies as the American Management Association, the Society for the Advancement of Management, the Industrial Management Society, and the Management Section of the American Society of Mechanical Engineers provide professional support to scientific management and publish the findings of their members.

PART II

FUNDAMENTAL CONSIDERATIONS IN INDUSTRY

CHAPTER 3

BASIC MANAGEMENT DECISIONS

Size. How large should a chief executive or his board of directors allow a business to become? Manifestly there can be no one rule. Even the smallest unit now existent in the automobile industry would be a tremendously large unit in almost any branch of the textile industry. A company manufacturing automobile parts should be prepared to produce the requirements of at least one of the automobile manufacturers if it is to survive today, and yet it must have at least enough additional business to prevent it from being put out of existence by losing its one large contract. Likewise, it should diversify its line sufficiently to prevent its being placed in a dangerous situation by a quick switch of its market away from the type of part it manufactures.

Once a company becomes successful, there is always the urge to expand the manufacturing facilities in good times to meet possible sales. Fine judgment is required to know how far facilities can be safely increased and when the decision should be made to sell only as much as the present plant can produce or as can be safely contracted out for manufacture. A closely knit organization which has been successful in building a business because of the close contacts and understanding among its respective members may become overstrained and weakened by the task of operating a much larger business in which the personal touch is not as important as carefully laid and integrated organization plans. There is a particularly big jump between a business sufficiently small for one man to oversee all the details and one so large that a single individual is unable to keep in touch with all its details.

An interesting announcement of policy concerning the size of a business was made by the Royal Metal Manufacturing Company of Chicago. President Irving Solomon of this company has said, "Sales of Royal

Furniture are purposely limited to $1,500,000 annually. Reasons: This permits the president personally to watch quality; to know each worker by name; salesmen are not harassed by constantly rising quotas, not high-pressuring unwilling buyers. If dealers cannot supply, buy from Royal's worthy competitors."[1] In another national advertisement the Royal Metal Manufacturing Company actually named six of its competitors, from whom it recommended that customers buy if the stated policy of the company did not make it possible to satisfy all of them. This policy is unique in American business, at least as far as public announcement is concerned, but the problem is one that requires a definite decision on the part of many executives.

The best rule that can be suggested is that a size be maintained that will always leave the company liquid from the standpoint of working capital, that will enable it to keep up with product developments in its field, and that will keep it large enough to influence the trend of products and style in its field. If the organization is not large enough to meet these requirements, it will be in the dangerous position of having to follow the lead of its important competitors and may run the danger of seeing an investment in machinery and equipment wiped out almost overnight by sudden trends away from its product.

Organization structure and trained personnel to assume executive positions are the controlling factors in the size to which an enterprise may grow. This statement, of course, is based upon the assumptions that the product is desired by the public in sufficient quantities to sustain the expansion and that the productive efficiency is such as to enable the company to meet competition. The growth of a business does not imply that the home plant may continue to expand indefinitely because freight costs of the finished product may dictate the construction of additional plants nearer the markets rather than the extension of the market of a single plant. General Motors Corporation operated 115 plants during the war. By following its philosophy of decentralized responsibility for operations with advice and coordination from the home office, this organization could have operated 150 plants if it had had sufficient trained executive personnel or had had time in which to train these executives. Multiple-plant operations require a different organization structure for maximum efficiency.

The decision to buy or make. How completely should the business be integrated? This question constantly arises in an expanding enterprise. It may be answered today by a decision to manufacture by adding

[1] Advertisement in *Time*, November 10, 1936. (As we go to press, the company is still following the same basic policy.)

a second shift and may arise again two years hence when the productive capacity of the second shift will no longer meet requirements. As conditions within or without the enterprise change, the decision should be reappraised in the light of the new situation. Although the profit aspects of a completely integrated business are recognized, there are many disadvantages incident to making materials or parts which can be bought as cheaply, or almost as cheaply, as they can be manufactured. Some of the factors involved are:

Why Parts Can Be Bought More Cheaply

1. Occasionally advantage can be taken of depression conditions to buy at less than the full cost of manufacture, including interest on investment and depreciation. This is particularly true of articles in which the field is highly competitive.

2. The processes incident to the manufacture of the part are often foreign to the remainder of the business.

3. There may be greater chance of obsolescence of the machinery needed to manufacture a particular part than in the remainder of the process. In such cases it is advantageous to allow another manufacturer to own such machinery.

4. The requirements of the business for the part or material may be only a small fraction of the total requirements for the material from other dissimilar businesses. Under such conditions buying will afford the independent manufacturer the advantage of others' large-scale purchases for his requirements.

5. At any given time the extent of capital available to a given business may make it more profitable for the business to utilize its capital in sales and other business promotional or research activities, rather than to tie it up in machinery and materials for the manufacture of portions of the product which can be purchased.

Why Parts Should Be Made

1. During times of prosperity, particularly when a certain product has taken the fancy of the buying public, it is sometimes difficult to secure prompt deliveries on rapidly rising requirements from usual sources of supply, and at such times new sources are difficult to develop with sufficient rapidity.

2. Processes into which hidden quality is put and which have much to do with the acceptance of a particular article can be more satisfactorily made by the company responsible for the quality guarantee.

3. On style merchandise, parts or materials which give clues to the appearance of articles to be made for a particular season sometimes may advantageously be kept from competitors as long as possible.

4. Particularly for large companies, the policy of manufacturing a portion of the most important parts provides a continuing yardstick concerning the proper cost of such parts and also a means of preventing suppliers from arbitrarily increasing price in times of greatest need.[2] Similar effects have been secured repeatedly by threatening to undertake the manufacture of some purchased part; often long-time contracts at favorable prices have been secured by this means.

[2] This also has the effect of letting the manufacturer's department operate at full capacity at practically all times, leaving the irregular overflow to the company from which parts are purchased.

Quality of product and price field. A fundamental decision which must be made by most manufacturers early in their existence and then reconsidered frequently is the price field in which they desire their product to compete. Not only will the decision which they make in this regard influence the basic quality of their product or products, but it will doubtless profoundly influence their manufacturing methods, machines, and personnel and also their basic methods of distribution. Lower-grade, volume products generally must be distributed on a wider, more inclusive scale than medium- or high-grade products. Profits per unit will be much smaller, but in so-called volume products the potential sales outlets are so much larger that their attractiveness lies in the greater potential profits which exist in most fields with this class of merchandise. The greater potential profits, however, entail at least three added problems: (1) more intense competition; (2) price pressure from distributors and dealers, often to the exclusion of regard for the intrinsic merit of the article; and (3) the costs of added plant and equipment if the article is favorably received. This requirement becomes increasingly difficult if the demand for the article is transitory.

It is difficult for management to resist the siren call of the distributor or dealer who wants low-priced merchandise. Frequently this merchandise is asked for "as a leader," with the assurance that there is no intention to push it, but only to use it as a means of attracting customers, after which they will be gently led toward the merchandise of higher grade with higher percentages of profit. With assurance of this kind from distributors and dealers many manufacturers have been led to produce merchandise selling for a considerable percentage under anything which they have previously offered. The manufacturer then discovered that once the snowball was started it could not be stopped, that the market had come to be educated to the new low prices as the proper amount to pay for the article, that a large proportion, if not a majority, of the sales were made in the new low-price brackets, with accompanying low profit margins, and that a whole new advertising and sales-promotion campaign would be necessary to bring public acceptance back to the higher-priced merchandise.

Sales outlets to use. Determination of the price field which a particular manufacturer will attack, or if he is going to aim at several price fields, the relative extent of each, is a problem which has to be considered continuously, and the decision becomes one of the basic factors in management. The type of sales outlets to be used may govern the decision, and conversely the decision may be governed by the type of outlet. For example, a manufacturer of gas stoves has a choice of several methods of distribution or of combinations of them, as follows:

1. Through public utility companies.
2. Through a distributor organization, with distributors utilizing specialty stores and hardware stores as outlets.
3. Through department stores, which ordinarily will not buy through distributors but wish to buy direct from the factory.
4. Through large stove stores in some cities, which ordinarily buy as do the department stores, but which may also act as distributors in their section.

Some of these outlets cannot be satisfactorily used competitively within the same district because of their divergent merchandising policies. In some cases it does not prove practical to sell through several types of merchandising agencies, even in widely separate districts, especially through public utilities and department stores. The reason is that the type of merchandise that they demand and the type of sales-promotion methods which they use are usually different. The department store has a series of sales scattered throughout the year to attract customers to the store, with unusual offerings in the way of prices as the particular inducement. For these sales the store must secure from the manufacturer "specials," which will be only slightly different in design and grade from regular merchandise, but which must offer values that will immediately prove to be outstanding to the customer, both in attracting him to the store and in effecting sales after he has been brought in. Only a few department stores can successfully, over a period of years, promote the sale of the more expensive, most completely equipped gas stoves. These articles have been distributed most successfully through the public-utility companies, the stove stores, or distributors.

The decision to distribute directly or through distributors is determined for any product by a number of factors other than quality. Some products can be most successfully distributed through distributors. Other products may be sold to retailers, whereas still others may be sold directly to the consumer. The custom in the trade will exert an influence; a strong organization, however, may establish its own custom. There is some difference to be considered between marketing a producer's heavy good and a widely used consumer's product. The former type may require a highly specialized technical knowledge not readily available among the usual distributors. Almost any product that can be named, however, has more than one channel of distribution, largely depending upon the managerial decisions of the particular enterprise. Such items as availability of funds, availability of desirable outlets, and credit policies, may be immediately controlling.

The decision to diversify. From time to time management is faced with the decision of whether to continue to make a single line of products or to manufacture other products, even in different fields. This is a dif-

ferent and more fundamental problem than the extent of diversity in products of a given type, which is considered under Simplification in Chapter 9. It is a decision concerning the number of fields of industry in which the company should engage. In recent years companies with large financial resources have shown tendencies to invest them in manufacturing products in related fields, particularly in articles which can be distributed through the same outlets. Other companies, however, have believed that their own future could best be assured by spreading their activities over widely divergent fields which would tend to assure them profits if their original field was slack and would give them the opportunity to utilize the managerial brains and experience which they had developed to produce additional profits for their stockholders. The development of General Motors from a corporation having only automobile manufacture as its interest, through a corporation having parts and allied products added to its first interest, to a corporation having large, diversified interests is a pertinent illustration. This corporation, in addition to its automotive divisions, covering the field from the lowest- to the highest-priced car, and its ignition, lamp, starter, foundry, gear, axle, and other plants, has secured a commanding position in the manufacture of electric refrigerators, electric motors (for both domestic and industrial use), diesel engines, air-conditioning units, and railroad equipment. More recently the Nash and Kelvinator corporations have combined their manufacturing and marketing interests. It is by no means a settled question that this type of expansion to secure diversity is entirely advantageous. In many instances, after a certain size has been reached, economies derived from further expansion are open to serious question. Strong individual producers are still succeeding in practically all the fields that have been entered by these larger corporations.

After World War II many companies, finding themselves with excessive productive capacity, took on new products in addition to the ones that they manufactured before the war. Their success was encouraging during the first year, but time alone will tell whether the decision was wise in the long run. It is one thing to succeed in producing an item for which there is a tremendous latent demand arising from war economy and quite another thing to meet keen competition during normal times.

How far should the relatively small company with capital only sufficient for its immediate needs venture in the diversity of product? This is a decision which cannot be made merely by copying the example of the large aggregations of capital, even though it becomes industrially more dangerous year by year to have all one's eggs in one basket. Should a company with a moderately successful experience over a period of years in the manufacture of polyphase electric motors for industrial use

invest a portion of its accumulated surplus to endeavor to wrest a portion of the attractive household electric-refrigerating motor business from its more powerful competitors? The company may have the technical and managerial skill to produce this new line of motors, even though they are single-phase and all its experience has been with polyphase motors. Questions that its directing heads will have to ask themselves include:

1. Do we have something to offer in an improved product which will cause the large accounts to buy from us instead of from the better-known and larger producers?

2. If our product is just as good or a little better, will we not have to sell it cheaper than our larger competitors in order to secure a portion of the business? And, if we do that, will not our competitors, with their greater financial resources, drive down the price still further, so that it will be unprofitable business for us?

3. Are we certain that our engineering ability will give us products which will stand up in quantity manufacture so that hidden defects in our first year's production will not cause large quantities of these high-production motors to be returned to us under our guarantee? If this happens, have we the financial resources to withstand one such setback?

4. Would not the amount of managerial and sales effort necessary to secure a portion of this new business be better expended in improving and enlarging our field of sales in the type of product which we have always made and which we fully understand?

5. If we secure the business of several of the smaller refrigerator manufacturers but are unable to secure any of the business of the larger ones, will the profits available from such business offset the costs of installing the tools and doing the experimental work necessary to enter this field?

The questions set forth in the example just given are not intended to be inclusive, merely suggestive. How much more thoroughly must the executives of a company question themselves when they are thinking of diversifying into entirely unrelated fields, even though much of the manufacturing work on the new product can be done on the same machines that are already in use! There is no substitute for ample funds with which to rectify mistakes and bridge over lean years when diversifying. These management problems help one to understand why large corporations are the most successful in consolidating units making diverse products and emphasize the fact that properly developed consolidations between two or more small companies are frequently more successful than attempts to expand the number of lines of products. It is fairly well established, however, that a diversity of products, either through consolidation or otherwise, brings problems of managerial control that require careful decisions regarding organization and policy.

Financial decisions. Financial decisions may be grouped under three main headings: (1) raising funds for the initial founding of the enterprise, (2) financing the "peaks and valleys" of a going enterprise, and (3)

changing the financial structure of the going enterprise and securing funds for expansion. The initial funds may be secured by the sale of common stock, preferred stock, bonds, some short-term borrowing, and other methods known to students of corporate finance. The fact that adequate funds are raised in the beginning does not settle this important item for all time. If the enterprise should prosper, it is quite possible that new plants, buildings, and equipment, as well as working capital, will be needed to care for the increased business. Even though adequate funds are available from operating profits, a decision is required as to whether these funds are to be reinvested or are to be distributed to the stockholders, the needed funds being raised by selling additional stock or other securities. There is also the question of the extension of credit to customers, which is basically one of finance. Again, profits may be high during a period of prosperity, and management may be forced to decide whether to distribute these profits as earned or to establish a policy of paying a moderate dividend during prosperous operations and thus build up a surplus with which to pay a dividend during lean periods. Many other types of decisions that management will be forced to make are of a financial nature, such as whether to carry its own workmen's compensation insurance, whether to share profits with employees, whether to bear a part of all the group employee insurance, whether to establish an annual wage, and what provision to make for management profit-sharing and credit policies. Many of these problems involve factors other than finance, but all are also financial in nature. A decision once made may not be final.

Managerial standards. In no place are managerial decisions tested more rigidly than in the establishing of standards. Managerial standards are basically the crystallization of managerial policies into formal measures and procedures. Managerial standards cover the entire range of business activity, finance, accounting, quality of product, organizational structure and procedures, requirements of divisional and departmental performance, executive remuneration in relation to profits, worker profit-sharing where it exists, purchasing, and selling. An effective standard can be established only after careful investigation, analysis, consideration of the objective to be attained, a harmonizing of conflicting interests, and agreement upon the basis of measurement. Temporary standards may at times have to be established in the absence of all the necessary facts or in a situation where time does not permit the harmonizing of interests or agreement upon the common measure. Such temporary standards, when established by persons having a broad background and keen insight, may develop into permanent standards when supported by experience. Standards act as stabilizers of activities and relationships. They relieve

management of the responsibility of caring for many details and enable them to concentrate on problems that have not as yet been solved. The details of standards are discussed under the various specialized chapters, such as those on equipment, product design, and time and motion study. It is important, however, in the consideration of management decisions to observe that management standards are the foundation upon which all other detailed standards are based. In the absence of seasoned managerial standards, departmental or functional standards are largely ineffective.

Plant location. The decision regarding plant location, when coupled with the decision to buy or build the plant buildings, is of far-reaching consequence. Such a decision involves large commitments of a relatively permanent nature and definitely reduces the ease with which the enterprise can adjust to changing conditions. Plant location both is influenced by and influences the nature of the product manufactured. Plant location also affects the nature of the organization. The economic and organizational features of plant location are of such importance that they will be explored in greater detail in Chapter 4.

CHAPTER 4

PLANT LOCATION

General considerations. The problem of locating a business enterprise arises under at least five conditions: (1) when a new business is being organized; (2) when a lease expires and the owner of the premises will not extend the lease; (3) when the business has outgrown its original facilities and additions have to be constructed or a new location found; (4) when the volume of the business and extent of the market make it desirable to establish branches for either production or distribution purposes; and (5) when other social or economic reasons exist, such as an inadequate labor supply, a shifting of the market, or a need to meet competing service given in a special market.

Plant location is often the result of a compromise among conflicting social, economic, governmental, and geographic considerations. The personal desires of the owners or managers (Fig. 4.1), often influenced by social considerations, may suggest one location whereas economic considerations will indicate another. Governmental factors are not so important in many instances, but they assume greater significance if the company desires to engage in foreign trade or if the country is at war.

Geographic specialization. Illustrations of regional specialization in industry are the manufacture of pottery in Trenton, New Jersey, and East Liverpool, Ohio; of brass in the Naugatuck Valley of Connecticut; of agricultural implements in Chicago; of firearms and fine tools in Connecticut; of steel in Pennsylvania, Ohio, and the Great Lakes region (Fig. 4.2); of carpets in Pennsylvania; and the scientific optical glass industry in Rochester, New York; and the rubber industry in Akron, Ohio.

Climatic conditions, natural resources, the general nature of the terrain, and the cultural heritage of the people are influences that explain in part regional specialization. Certain types of manufacture, such as the textile industry, require an atmosphere having a high relative humidity. Recent developments in artificial air conditioning, however, have eliminated this regional advantage to a large extent.

Large consumers of coal for fuel or as a material from which products are derived are naturally located as near the source of supply as other

economic factors permit. Throughout the ages natural mediums of transportation, such as rivers, lakes, and the ocean, have been influential in determining the location of cities through which commercial traffic passes. Wherever an abundant labor supply exists, there are conditions favorable to industrial specialization, especially if a cultural heritage of the people

Courtesy, Clark Equipment Company, Buchanan, Mich.

Fig. 4.1. Plant location in a small town.

that is in harmony with the specialization exists concurrently. If to the abundant labor supply and favorable cultural heritage the fortuitous circumstances of an early start are added, industrial specialization logically follows. On this basis regional specialization in American manufacture is largely explained. It is not quite so easy to explain just why a particular industry should have had an early start in one place or a few places except on the basis of leadership, and leadership is not always easy to break down into its elements. The willingness of the people in a given community to invest their funds in an untried enterprise is fre-

quently as important as inventive genius. The Chamber of Commerce of Detroit encouraged the building of automobile plants in that city.

Major factors in locating a business. Plant location in a particular region is largely influenced by: (1) nearness to the desired market; (2) the local and regional tax situation; (3) nearness to the source of raw material; (4) an adequate supply of labor; (5) transportation facilities; (6) climatic conditions; (7) governmental factors; and (8) the availability of water, power, and fuel.

Courtesy, "Ford News Bureau Photo"

Fig. 4.2. The Ford Motor Company plant, Dearborn, Mich., is located, on the navigable River Rouge, in a suburb of Detroit.

The exact location. Within a given area or region the exact location is governed by: (1) the availability of land to meet current requirements and the needs of future expansion, as well as the relative cost of this land in comparison with other cost factors; (2) nearness of other industries upon which the given plant may be dependent; (3) transportation facilities for raw materials, finished products, and employees; (4) availability and characteristics of the labor supply; (5) importance of the local market; and (6) community restrictions and, in some instances, community aids.

A plant manufacturing a product to be marketed in the upper Mississippi Valley and the Great Lakes region might well consider the Chicago

area, although several locations within a radius of seventy-five miles would meet the regional requirements. Nearness to the market, definitely tied in with the transportation problem, is also influenced by the question of the time element in giving prompt service, technical advice, and in the ability to adjust to the trends in the given area. The labor supply, particularly for a small enterprise, is usually more satisfactory in or near a city. *Nearness to the source of raw material is of special importance when this material is bulky in relation to its value and when the volume and weight are greatly reduced during the processing.* If the volume of the raw material is small in comparison to that of the finished product, the plant will usually locate near the market instead of near the supply of raw material. Raw materials that are rendered less perishable by the manufacturing operation are nearly always processed near their source.

Transportation facilities and costs may dictate one location of a plant when the other factors are strongly in favor of another location. Water transportation nearly always costs less to the consumer than rail or truck transportation. For this reason the Ford Motor Company has located many of its assembly plants on navigable waters. This practice, whenever possible, is common for industries having large volumes of freight. A region that has adequate rail, water, and truck transportation is definitely to be preferred for the manufacture of a product for a large market. The size of a given market that can be economically served by an individual plant is greatly influenced by transportation rates. As far as transportation is concerned, *plants tend to be located in the locality where the aggregate transportation costs are the least.*[1]

Governmental factors are important from a regulatory and licensing standpoint. Taxes must also be considered. Many industries manufacturing for export have established branch plants in Canada and Australia to gain the advantage of a favorable tariff in the United Kingdom.

After the decision is made to locate a plant in a given region, the selection of an exact site is influenced by the factors which have been listed. The availability of land to meet current requirements and future expansion needs is always important. The manufacturing process may be more easily handled in a single-story building, which will require a larger area. If land values are too high, less land space will be used, and a multi-storied structure will have to be built. Provision for expansion is important and often results in great economies in later development.

An industry that uses a by-product of another plant as its raw material or is a service plant to other plants naturally should be located, in so far

[1] D. Philip Locklin, *Economics of Transportation*, Business Publications, Inc., Chicago, 1935, p. 114.

as is possible, in the vicinity of the other plant or plants. In this way freight charges are reduced, and the service rendered is improved.

Local transportation for raw materials may be handled by truck if the volume is relatively small, yet even in such cases rail and water transportation is often advantageous. The presence of transportation facilities for employees or location of the plant near their homes may be reflected in the labor expense as well as in the character of the labor available. Many employees use their own automobiles, but this method of transportation requires parking space, which is often prohibitively expensive in high-priced land areas. Low transportation costs and nearness to the homes of the workers are particularly important for industries using large numbers of common laborers or semiskilled workers.

Community restrictions, such as requirements for the disposition of wastes, smoke regulations, and zoning laws, are often controlling factors. For other reasons an area reserved for residential purposes may be a desirable location for a plant. Nearly always, however, an industry in its capacity as a good citizen is unwise to try to break down community regulations, even though it proceeds through regular channels. Recently a large manufacturer of automobiles decided to locate a branch plant in another city because some of the residents of the one that had been selected protested the nearness of the site to a residential section.

The local market is of minor importance to the large-scale manufacturer having a wide distribution of his product. It is important, however, to the small manufacturer and the manufacturers of bakery goods and other perishable food products.

The big-city location. Most of the advantages of the specialized region are to be found in greater abundance than elsewhere in the large city (Fig. 4.3), where there are also unusual educational and amusement advantages. Not only does the city offer educational advantages for the children of the employees, which may make parents desirous of being in the large city, but also, and more important, there are opportunities for trade and industrial education. Evening schools for the workers, which make them more valuable to their concern and to themselves; discussion groups for the executives, such as advertising clubs, production, and engineering organizations; foremen's training classes; and many other types of modern industrial educational facilities are to be found in the big city. These advantages can also be enjoyed by a firm located in the suburbs, provided transportation facilities are adequate.

In the large city there is always available a more diversified working force than in smaller communities. It is nearly always possible to secure male or female labor as is desired. Specialized communities that em-

ploy only male labor always tend to build up complementary industries employing women, regardless of the size of the community.

In the eyes of many industrial executives, however, the advantages of big-city location are offset by disadvantages. For instance, the small plant is likely to be at a disadvantage in a big city because it may be forced to find a location in a loft building. This type of factory building is particularly common in New York, but it can be found also in almost

Courtesy, Bridgeport Brass Company

FIG. 4.3. A large plant in a large city on a navigable river.

every other large manufacturing city. The loft building is the refuge of the man who seeks to take advantage of a labor supply near at hand, as in the clothing trade in downtown New York or the textile industries of northeast Philadelphia. The loft building makes difficult the development of modern management not only in the company that uses it but also in the entire industry near by. It is difficult to maintain working standards against the type of manufacturing competition that rents a floor, rents machines, forgets the existence of overhead, and proceeds to make hay during the sunny times of industry. On the other hand, some enterprises in loft buildings meet all the requirements of modern management.

Some years ago there was a tendency to locate big-city plants in the center of a thickly settled manufacturing district. With the development of high-speed transportation within great cities this condition has

changed, and within the boundaries of these cities new plants are locating under conditions which approximate the suburban location. In fact, arbitrary boundary lines are frequently the only difference between city plants and suburban plants. In medium-sized cities attractive settings have always been possible, as at the plants of the Eastman Kodak Company in Rochester, New York, and the National Cash Register Company of Dayton, Ohio.

In summary, the advantages and disadvantages of the big-city location for a plant may be said to be:

Advantages

1. Adequate supply of labor.
2. Presence of subsidiary, service, and related industries.
3. Frequently easier financing of the enterprise.
4. Large local market for product, of particular importance to the small plant.
5. Usually extensive social and educational advantages for employees and executives of the firms.
6. Greater availability of trunk-line rail and water transportation.

Disadvantages

1. High taxes.
2. High labor costs, since living costs and wages are usually higher in large cities than in smaller ones in the same region.
3. Labor relations at times less friendly in larger cities than in small communities.
4. Scarcity of available sites that provide room for expansion, and expensiveness of the land.

The small-town plant location. Although small towns do not have a diversified labor supply, and although trained labor for a new industry usually is absent, this disadvantage is partially counterbalanced by the fact that the town's industries are not likely to absorb the total available labor supply of the community. This has become particularly true since women have entered so extensively into industry. In general the labor relations between employers and employees are favorable in the small community, at least in the early stages of the plant's development, and usually continue on a friendly basis when the management follows an enlightened labor policy. Although the labor supply is untrained, it is more easily trained in the technique of a given industry than is labor in a large city, because the absence of alternative opportunity makes the workers desirous of learning.

Many of the advantages of the big city are not found in the small town. A diversified labor supply, amusements, and other features are usually lacking in greater or less degree. It is an important fact that high-grade executives tend to locate near the larger cities.

The small town, however, offers certain very definite inducements that the large city cannot give. A supply of land suitable for constructing a plant to meet current requirements with ample room for expansion is available. Undesirable manufacturing neighbors are not likely to be present. Municipal regulations are seldom burdensome. Low taxes, sometimes coupled with definite rebate of taxes, are another favorable factor. Many small towns donate land or even erect buildings and give bonuses to large industries to locate within their borders. There is a real danger in placing too much emphasis on such factors if more basic conditions are not advantageous.

The suburban location. The suburbs of a city provide practically all the advantages of both the large city and the small town with relatively few of their disadvantages. This fact accounts for the very rapid development of the "metropolitan districts" near large industrial centers during recent years. In the suburbs there is adequate land for the one-story structure. The ground is relatively cheap, and the taxes are comparatively low. The advantages of the big city near by can usually be enjoyed by the staff sufficiently often to keep the workers contented, particularly if the housing conditions in the suburb are as good as or better than in the city. Railroad facilities in the suburbs are usually as good as they are in the city. In fact, they are likely to be better, in that spur tracks are easier to secure and can be arranged to suit the needs of the plant. All the advantages of having several competing railroad lines, which are usually found in a large city, may be enjoyed.

The specialized community. Management problems are simplified in a variety of ways by a plant location near other similar industries. Not only is there a trained labor supply available in such localities, but also the ease of financing the business and selling the product is enormously increased. Examples are flour milling in Minneapolis, cotton spinning in the manufacturing districts of the South, automobile manufacturing in Detroit, and rubber manufacturing in Akron.

The banks in such communities are familiar with the needs of the business, have a knowledge of good business practice in the industry, and usually are willing to aid in any legitimate way to the limit of their ability. Other industries, on initially locating in one-industry communities, frequently find it extremely difficult to secure the cooperation of bankers in handling their accounts. Sometimes they are forced to go out of town for accommodation in times of extreme need.

Buyers gravitate to localities in which an industry is centered. Sometimes, indeed, a dominating market can be established in the town in which the goods are manufactured. Thus buyers gravitate to New York for the purchase of women's clothing.

Another benefit of location in a specialized community is the proximity of machinery manufacturers who make the type of equipment used in the industry. Required machinery can be procured on short notice, and, more important, repairs to machinery can be secured quickly. If the machinery manufacturer himself is not represented in the specialized center, it is probable that repair shops will soon spring up. This advantage appeals particularly to companies which are not large enough to maintain their own repair departments.

Some manufacturers have encountered certain disadvantages in the highly specialized areas. Specialization within an area facilitates the unionization of labor within the industry. Manufacturers who do not desire to employ union labor have found this a sufficient cause for moving outside the area. Other manufacturers who are not opposed to dealing with unions have moved their plants because of an unfavorable labor situation in some specialized communities. In times of depression specialization within a community leads to much "shopping around" by purchasing agents, and therefore the fact that they come to the market to buy is not an unmixed blessing to the manufacturer.

Location advantages of the large city, the small town, and the suburb. A plant may locate in a specialized section and still have a choice of a large city, a small town, or a suburb of a large city. Such a choice is to be found particularly in such sections as the shoe region of New England or the automobile regions of Ohio and Michigan.

If the specialized area is a great city, many of the advantages of location within the city can be gained by a location near by, and at the same time some of its disadvantages may be avoided. Thus the automotive plants of Pontiac, Flint, and Jackson, Michigan, enjoy most of the advantages of those located in Detroit, without being faced with the transportation problems or the taxes incident to location within Detroit. The tax problem has played a major role in locating new plants that are branches of larger parent organizations. Pontiac and other "satellite" cities owe their industrial growth largely to the high taxes of the larger cities. This tax differential tends to disappear with the passage of time and the growth of these satellite cities.

Economic survey frequently shows that the large city offers special advantages to the small plant, that the suburbs of a large or medium-sized city are best suited to the fair-sized plant, and that the small-town or rural location has much to offer the very large plant in a position to attract its labor supply and able to aid in the housing situation. This is a very broad generalization to which there are innumerable exceptions Each individual situation should be analyzed in terms of its peculiar needs and requirements.

The economic survey. Industrial engineers and market analysts have developed techniques for determining with fair accuracy the volume of business that may reasonably be expected from a given market area, and the plant location that will make possible the delivery of the product to the consumer in this area at the lowest unit cost. That plant location *is best which results in the lowest unit cost in producing and distributing the product to the consumer.*[2] Determination of it is seldom controlled by one factor alone but is usually the resultant of many economic forces,[3] including: (1) incoming freight expenses, (2) cost of fuel, power, and water, (3) cost of plant site, (4) building costs, (5) labor costs, and (6) freight costs for the finished product to the consumer. With these costs and assumed volume of production, an operating statement can be constructed or a cost analysis made that will indicate certain definite preferences concerning location.[4] Most of the data required are readily obtainable from current prices and published schedules for the communities under consideration. Labor costs are usually computed on the basis of the prevailing rates in the community for common labor. Land sites can usually be determined locally by an actual bid or offer. The nature of the land site may determine to some extent the building costs. Labor rates, a large factor in building construction, vary considerably in different localities.

This survey may readily be divided into two main divisions: (1) the cost of the building and equipment, and (2) the operating costs. The building and site cost should be accumulated in some such form as the following:

	Location A	*Location B*
Land	$ 50,000	$ 40,000
Buildings	900,000	855,000
Equipment	125,000	125,000
Water and power	35,000	10,000
Special requirements, if any:		
1. Grading	10,000	1,000
2. Railroad siding	Present	5,000
3. Roadways	1,000	3,000
Total cost	$1,121,000	$1,039,000

[2] W. G. Holmes, *Plant Location,* McGraw-Hill Book Company, New York, 1930, p. 3.

[3] *Ibid.*

[4] See E. L. Grant, *Principles of Engineering Economy,* Ronald Press Company, New York, 1938, pp. 126–129, for an illustrative computation of relative costs for various locations, and also William B. Cornell, *Organization and Management in Industry and Business,* Ronald Press Company, New York, 1936, p. 178.

The comparative statement of operations for the two sites would be something like the following:

	Location A	*Location B*
Freight expense:		
Incoming	$ 50,000	$ 55,000
Outgoing	80,000	78,000
Power and water	45,000	42,000
Fuel	30,000	20,000
Labor	450,000	427,500
Total cost	$655,000	$622,500

From the foregoing hypothetical figures *Location B* has a lower ground cost, building cost, water and power cost, grading cost, but a higher roadway-construction and railroad-siding cost. The net cost is in favor of Location B. In terms of operations the costs at Location B are also most favorable, and it is evident that Location B is closer to the total market. From a purely economic standpoint this would be the natural site to be selected.

Some persons overemphasize labor costs in selecting a plant site. The relative importance of any of the cost factors has to be carefully scrutinized. Labor costs vary all of the way from six per cent to seventy per cent or more in different industries. In the final analysis, from an economic standpoint the total-cost relationship rather than any one item is likely to be controlling.

Social and governmental factors in plant location. To move a plant from one location to another involves many social dislocations. Labor is by no means as mobile as many persons are likely to believe. Deep-rooted ties and sentiments bind workers to a location where they have their friends and sometimes own their homes. Some communities become almost ghost towns when a key industry moves out, and thus serious problems are created for the local and state governments.

In time of war the factor of national safety is important in the location of key industries that are a part of the national effort. The federal government has little, if any, control over the peacetime location of plants, but it enters actively into their location during war. For instance, the location of aircraft plants near the coast is of vital concern in time of war. It is conceivable that a cooperative peacetime program between management and the government might lead to great advantage in a national emergency. It would be a dangerous practice, however, for the federal government to exercise any major influence upon the location of most plants, for political considerations usually do not promote economic efficiency.

Decentralization of industry. For many years American industrial plants tended to grow in size, partly influenced by economies in mass production and partly from the American attitude toward "size." In a strict sense building plants away from the home plant to care for needed productive capacity is not decentralization, but rather a change in the trend from increased centralization. The transfer of production to outlying plants, thereby decreasing not only relatively but actually the production in the central plant, constitutes decentralization.[5] Much of the geographical shifting of production involves in reality enlarged or increased production in areas hitherto not actively engaged in this type of production, rather than a decrease in the actual production in the old plant or area. Since the older production areas and plants may not be increasing production at the same rate as the newer ones, opportunity for the expanding population in this area to find employment is not so favorable as formerly. This situation naturally raises grave social, economic, and governmental problems. Manufacturing tends to follow the shift in population, and population tends to increase in manufacturing centers, thus establishing a reciprocal relationship. Both population and manufacturing centers tend to follow economic opportunities closely related to the abundance of natural resources.[6]

Other factors influencing the growth of industries in new regions (which is what many people mean when they speak of decentralization) are: (1) favorable labor legislation or labor relations in the new area, (2) lower labor costs, (3) nearness to the source of raw materials, (4) cheap electric power, as in the T.V.A. region, (5) lower taxes, and (6) special inducements in the form of free land sites. Some manufacturers think that there are long-run social and economic advantages in having industry more widely distributed than was the trend at the beginning of the twentieth century. There is little likelihood, however, that a large number of widely scattered, self-contained small industrial units will develop. It is more probable that the next step in the evolution of regional plant location will be a highly integrated system of plants decentralized in process but directed by a unified management. The location of the manufacture of steel has to a large extent followed its market. Pittsburgh is still a large producer of steel, but so also are Chicago, Detroit, Cleveland, and Birmingham.

Industrial housing. Most of the publicity that industrial housing has received has not been favorable. There is a prejudice against industrial

[5] William N. Mitchell, *Organization and Management of Production,* McGraw-Hill Book Company, New York, 1939, Chapter IV, especially pp. 62–69.

[6] The population center of the United States, according to the 1940 Census, is near Carlisle, Indiana.

towns which must be overcome by the individual company. Early attempts in the construction of industrial towns were largely failures because they were built on a paternalistic concept which was unsound.

The company has a proper interest in the living conditions of its employees, provided that it does not carry that interest to paternalistic extremes. The worker who is in a plant for an eight-hour day is there only about one quarter of the year. It is generally recognized that conditions in the plant affect a worker's health. His health is affected even more by conditions in his home. Health and production are directly related. The costs of labor turnover will be decreased if the employee can live in a better home by working for a particular company. The cost of replacing employees may be found to be larger than the interest rates on the money that a company ties up in aiding an industrial housing project.

Industrial houses may be company owned and may pass into the hands of the worker through the financial assistance of the company; may be owned by a separate corporation, in turn owned by employers and employees; or may be owned by persons not connected with the company. For the company to own permanently a large share of the houses in a town or village is likely to result in the alleged exploitation or other abuses that have brought condemnation upon industrial housing projects in the past. It is generally more advisable for the workers' houses to be built by a separate corporation and to be sold to the employees. The operating company may have to take the initiative to get the program under way, but it should be as inactive in the management as is consistent with the protection of its investment.

PART III

ORGANIZATION STRUCTURE

CHAPTER 5

ORGANIZATION DEVELOPMENT

Functions of the executive. The functions of the chief executives are planning, organizing, and controlling.[1] Planning in this sense refers to the over-all planning, an administrative function, not the detailed planning of operations. Control refers to the regulatory activities of top management which are largely executed through organization channels. Organization is the foundation of most of the steps of operating management. Proper organization simplifies management in ways which are impossible in a business that is not well organized. Much of the criticism which has been leveled at certain methods of management in particular enterprises should instead be aimed at the faulty organization that made impossible the laying of the groundwork on which these methods should have been based. Organization is not an end sought in and of itself but rather a means to aid in the attainment of the institutional objective. It creates an atmosphere in which effective collaboration may be realized.

Ordinarily the poorly constructed organization is typified by executives at the top who are struggling continually with a mass of detail, who point to their terrific burdens, and who perhaps feel that they are not able to take a vacation once in five years. The organization which is well constructed is typified by the smooth flow of detail throughout the executive organization and by chief executives whose minds are free to think constructively about important matters.

Definitions. The term *organization* has been used in a number of different ways by different authors and often with at least two meanings by the same author.[2] *In its broadest sense it refers to the relationship between*

[1] See Ralph C. Davis, *Business Organization and Operation,* H. L. Hedrick, Columbus, 1937, p. 25.

[2] See E. H. Anderson and G. T. Schwenning, *The Science of Production Organization,* John Wiley & Sons, New York, 1938, pp. 9–15, for a detailed discussion of the various usages of this term.

the various factors present in a given endeavor. Thus land, labor, capital, and the entrepreneur may be combined in various relationships to produce an economic organization. Factory organization concerns itself primarily with the internal relationships within the factory, such as responsibilities of personnel, arrangement and grouping of machines, and material control. Viewed from the standpoint of the enterprise as a whole, *organization is the structural relationship between the various factors in an enterprise.* It is the structure within which the various factors operate to achieve the objectives of the institution. Organization is sometimes used to refer to the personnel functioning within a given structural setup or to the functioning unit as a whole. These two uses of the word seldom cause any great confusion.

System is a mechanism of management functioning within an organization. *System* is subsidiary to organization and *arises when procedures have been standardized.* It is the crystallization of procedures whereby the efforts of men and departments are coordinated and integrated. System is *regulatory in nature* and not within itself constructive, although it may be a means of simplifying constructive effort. System is not an end in itself and must be carefully used if it is not to develop into *red tape.*

Basic considerations in organization. Organization refers to the structure of the enterprise, especially from the standpoint of the development of the duties and functions of its parts. The purpose of building up an organization is to provide for a daily routine and effective operation of a business or department with a minimum of direction from above. Organization carries out its purpose by determining the scope and limits of each individual or group of individuals in a business undertaking, together with their relationships and contacts with each other. After considering the fundamentals and types of organization, an executive builds up a structure for his business or department which is peculiarly suited to its needs. Organization should be dynamic; it should be changed to meet changing conditions.

Organizations must be developed primarily with regard to peculiar conditions within the business. The application of the fundamentals of organization will differ widely in two different businesses. The size of a business, particularly, has an effect on the way in which the organization develops. On the whole, in the small business it is possible to develop essentially the same type of organization as in the large business, except that the duties of several people in the large business will necessarily have to be combined in the small one.

The type of business will be found to affect greatly the development of the organization. Thus it will be found that steel plants, textile mills

paper mills, or refining plants, although they have the same fundamentals to deal with, will necessarily make different decisions. In a manufacturing business, if the product is standard, ordinarily the organization will need to be differently constructed from one handling a diversified product. The same amount of business may be handled with fewer chief executives if the product is standard, because it is easier to delegate authority in such industries. Even the location of a plant or of the departments within a plant may affect the exact way in which the organization is constructed. The effect of location on the personnel may demand this adjustment.

To build up an effective industrial organization requires proper observance and application of a series of "fundamentals of organization." These fundamentals fall into two main groups, primary and operating. The primary fundamentals should be considered by the executive in building the organization and before giving any considerable attention to the operating fundamentals, which aid in the application of these primary fundamentals to the business. The primary fundamentals of business organization deal with those phases of management which include policy formulation and organization structure. The operating fundamentals deal almost entirely with the operating phase of management.

The fundamentals of organization. The primary fundamentals are fourfold:

1. Regard for the aim and objectives of the enterprise.
2. The establishment of definite lines of supervision within the organization structure.
3. The placing of fixed responsibility among the various persons and departments within the organization.
4. Regard for the personal equation.

The operating fundamentals, which are also four in number, are:

1. The development of an adequate system.
2. The establishment of adequate records to implement the system and to use as a basis of control.
3. The laying down of proper operating rules and regulations within the established organization in keeping with the established policies.
4. The exercise of effective leadership.

The operating fundamentals of organization establish the groundwork for the third of the major divisions of management—operating the enterprise.[3] The first of the primary fundamentals, regard for the aim of the enterprise, serves to tie the developed organization closely to the determination of major policies, which is the first of the three major tasks

[3] See Chapter 1, p. 13.

of management. Thus, through the construction of an effective organization, major policies are followed in operations.

Regard for the aims and objectives of the enterprise. Regard for the aim of the enterprise is the first of the primary fundamentals. It is most important at the time when the first steps are taken in the building or development of the structure which is to be termed the organization of the enterprise. In no two businesses are the purposes of the management or the conditions of operation entirely alike. It will be easiest to consider this fundamental of organization by considering businesses of diverse natures, whereby it can be seen that the organization structure must necessarily be different in order to meet the several conditions involved. Let us consider the organization which is necessary to take care of the unusual situation in which speed of attainment and not cost is the dominating factor. Such an instance is clearing of a railroad right of way after a wreck. All thought of cost is thrown aside, and an organization is constructed which has but one end in view, namely, clearing the tracks and letting through the trains at the earliest possible moment. Compare this to the organization necessary for the operation of a huge manufacturing plant which is to remain in existence for many years and whose activities are not only numerous but varied and must all be carried on with due relation to each other. It will readily be seen that the organization structure required to meet the emergency of the railroad wreck will be simpler and more direct than that required to carry on the work of the great manufacturing enterprise.

Length of life of the organization and desired speed of results are important factors in the development of its structure. Thus the organization necessary to construct a number of reviewing stands for a large parade, which will be put up quickly and taken down promptly, may be far simpler than the intricate organization of a construction enterprise involved in putting up a huge office building or hotel. As the purpose for which or the condition under which the enterprise operates changes, the organization must likewise change. In determining the aim of an organization, major plant policies must be carefully thought through.

The establishment of definite lines of supervision. The establishment of definite lines of supervision lays down the policies of control which are exercised over the personnel of the enterprise. These lines of supervision may be looked upon as lines of authority, as paths along which orders flow. They are also the paths along which information necessary to the execution of particular tasks is communicated. It must be kept in mind that this path of communication is two-way; not only must instructions flow down but also reports must return along the same lines. Care must be exercised not to check the free flow in both directions.

In laying down the lines of supervision, the organizing executive has two main problems at hand. First, he must determine the type of organization to be used. The particular types of organization structures are described in Chapter 6. Second, he must carefully develop and mold the outlines of the type as they can be best applied to his particular business enterprise. In developing his definite lines of supervision he will have to give careful attention to the fourth primary fundamental—regard for the personal equation.

A lack of definite lines of authority will result either in an overlapping of duties or in gaps which are not taken care of by the organization as constructed. On an organization chart such gaps or overlaps may be thought of as *horizontal* and existing between the lines of authority which have been laid down, as contrasted to *vertical* gaps or overlaps, which will occur if the third of the primary fundamentals, namely, the placing of fixed responsibility, is not adequately handled. Lack of definite lines of authority will result in dissension among whole departments of the organization, and thus the personal attention of chief executives must be directed to the problems that arise.[4]

Definiteness of control through the establishment of lines of supervision implies the idea of the scalar principle or *tapering authority*. It implies the development of a group of executives in accordance with the plan of supervision, each one down the line having somewhat less authority in scope and somewhat more direction of detail. The job boss, although he has control over a small fraction of the business undertaking, is not charged with error if the undertaking has been wrongly conceived and has proved to be generally unprofitable.

At every step in the scalar chain of supervision there should be someone in charge. The organization structure should also provide for someone to take the place of the regular supervisor when he is not available because of vacation, illness, death, or resignation. This does not mean that there must be an individual substitute for each position, for so many qualified understudies are unnecessarily expensive for the small enterprise. It is frequently possible to train one man to substitute for several supervisors.

In small businesses the desire to have a substitute for each executive sometimes has led to a surplus of executives. It is never profitable to carry this idea to the point where additional executives must be put on the payroll. This consideration is often a real one, as, particularly in

[4] See James D. Mooney and Alan C. Reiley, *The Principles of Organization*, Harper and Brothers, New York, 1939, Chapter III, for a scholarly discussion of the scalar principle.

small businesses, there is often a wide difference in caliber between the executive head of a department and anyone else in his department.

The placing of fixed responsibility. To place responsibility accurately eliminates vertical gaps or overlaps of responsibility along the lines of supervision which have been laid down. Functional definition of the exact area for which an executive or worker is responsible is the third step in the *scalar principle.*[5] Standard practice instructions setting forth in detail the exact limits and responsibilities of each job and position are part of an efficient organization structure. It is sound procedure to *fix responsibility as far down in the organization as competence and the necessary information exist.*

Three main results are achieved through accurately placing responsibility:

1. Fixed responsibility acts as an incentive to a subordinate. This is particularly true in large organizations.
2. Fixed responsibility aids in the general speed-up of work. It immediately becomes possible to know to whom communications should be addressed or which executives should be called into conference on any particular topic.
3. Accurate placing of responsibility assists in developing discipline as a means of control.

Regard for the personal equation. By regard for the personal equation is meant consideration of the abilities and limitations of individual men and women. In developing lines of supervision and in fixing responsibility, it is not possible to consider only the factors of the business which would ordinarily demand that decisions of a certain nature be made. It is necessary to take into account the personnel which is available or can be made available. Frequently men have been shifted in an industrial organization as if they were all of equal value, as if one could readily replace the other, or as if one could always fit into an organizational niche when another had gone merely because he was a man of approximately the same salary or had previously performed almost the same duties. Men are of different values and work together in different ways. Frequently it is necessary to consider the man who is available and then draw the outlines of the job to fit his capabilities.

Merely assigning duties to men does not lead to the accomplishment of tasks, and therefore it is not always possible to draw organization charts and find men to fit them. This does not mean that a defective organizational structure should be continued indefinitely merely because at a given time men with the proper qualifications are not available within the business. The scientific manager will either train his men to meet

[5] *Ibid.*, p. 14. Mooney and Reiley list leadership, delegation, and functional definition as the three factors in the scalar principle.

the standards of the desired organization or will seek them on the outside. At a given time, however, compromises may have to be made. Some enterprises with branch establishments have organized each branch in exactly the same way, having for each branch organization charts which are exactly the same. It is an outstanding fact that in some of the branches of such organizations it will be found that everything is working smoothly, that everyone cooperates with everyone else; whereas in other branches jealousies have arisen, dodging responsibilities is prevalent, and the organization seems to be generally ineffective. The main difficulty is that, although the organization has been outlined, the lines of supervision have been drawn, and the responsibilities have been fixed, the personal equation—the abilities and limitations of the men and women—has not been taken into account.

It is difficult to enumerate all the factors which should be considered in giving proper regard to the personal equation as a factor in organization. There are several such factors to which attention should be directed. In the first place, proper consideration must be given at times to home conditions and outside worries. It is well enough to say that men and women should keep their social affairs outside the business, but unfortunately human nature frequently does not permit this. Secondly, the habits and inertia of the personnel of an organization must be considered. For just this reason new organizations are easier to construct than are old organizations to reconstruct. The "efficiency man," who developed so much trouble for himself, frequently did so because he refused to consider the habits or inertia of personnel involved. They gave lip service to the suggested changes but did nothing about putting them into practice.

Adequate system. The operating fundamentals are concrete in nature, as compared to the more abstract primary fundamentals, and, being readily seen by the casual observer, are easily misunderstood for organization itself. System is a part of organization, not the whole of it. As an operating fundamental it helps to bind the whole mechanism of organization together. System is the existence of order and method in all parts of an undertaking. System implies a formalized procedure that is to be followed in the handling of standardized activities. It relieves the man at the head of the details of execution and is a bulwark that prevents the lines of authority which have been laid down from being overstepped. It insures that work will be brought to executives with the preliminary steps completed and ready for their attention, thus enabling them to apply their entire time to matters of maximum responsibility. When all factors in a business are moving in a regular and accustomed routine, the waste of time and effort involved in repeating the preliminary

steps of the solution of any problem is avoided. It is the function of system to safeguard this routine, to provide in advance for all detail work, preliminary or consequent.

Although system implies order in work, it does not necessarily imply economy. A procedure may be highly systematic but still be very wasteful. Balance is needed in the establishing of systems as well as in all other managerial activities.

The "exception principle"—a development of system. System supplies the motive power for what has been termed the "exception principle" of management. Under this principle, the head of an enterprise, of a department, or even of only a few men does not attempt to act personally on each case coming under his general jurisdiction; he acts on the exceptional matters only. Frequently recurring matters are made routine, a system of checks and balances having been developed in accordance with responsibilities already fixed, so that these matters may be handled entirely without reference to the executive himself.

In discussing the exception principle Frederick W. Taylor said:

> Under it the manager should receive only condensed, summarized, and *invariably* comparative reports,[6] covering, however, all of the elements entering into the management, and even these summaries [6] should all be carefully gone over by an assistant before they reach the manager, and have all of the exceptions to the past averages or to the standards pointed out, both the especially good and especially bad exceptions, thus giving him in a few minutes a full view of progress which is being made, or the reverse, and leaving him free to consider the broader lines of policy and to study the character and fitness of the important men under him.[7]

Through the operation of the exception principle all routine matters may be handled by the executive in a few minutes, and thus he is enabled to devote his entire time to the more important matters which should, by right, demand his personal attention. He may devote more detailed consideration to the peculiar cases that do not fall under the routine. In devoting his attention to these matters, he frequently works over them to such an extent that he can correlate them and develop the points of similarity and difference among them, until they, too, are classified and routine and no longer may be termed exceptional.

[6] The executive must exercise care not to have this editing process function in such a manner as to keep from him vital information about employee unrest and similar items. Sometimes his assistants think that he should not be bothered with such details, which, however, are often more important than other items reaching his attention.

[7] Frederick W. Taylor, *Shop Management,* Harper and Brothers, New York, 1911, p. 126.

Systematic management. Systematic management is a considerable advance over rule-of-thumb method, yet it is far from modern scientific management. Systematic management represents a rather full development of system within an organization, without a corresponding development of the more thoughtful processes associated with scientific management. In plants where this type of management is found the executives are methodical in the extreme, and in some departments the smoothness of operation is very high. In systematic management considerable attention is devoted to all the fundamentals of organization, the greatest being given to the execution of orders through the development of a complex but generally effective system. It is in this type of management that the importance of the office clerk and bookkeeper reaches its peak, as compared to the situation under the thoughtful direction of the real executive.

Reports as an aid to management. Just as an order should communicate all information necessary for execution, so a report should contain all the data essential to appraisal of performance. A report in part discharges the responsibility of a subordinate to his chief. It is the completion of a task, the end of an assignment of work to be done.

The primary requisite of a report is that it serve a really useful purpose. Some men require the submission of reports which are of little practical value. If reports are to be an aid to the operation of the exception principle, this situation must be avoided. Otherwise the reports will not be read and will not serve as the basis for action.

The submission of reports is one of the most important functions of the young man who is just entering the field of management and who secures a minor executive position. If such a man properly can present the subject at hand for the consideration of his chief, he has found a sure way to secure the approbation of his superior. The ability to prepare a concise report which comes directly to the point at issue, covers all the necessary facts, and at the same time does not waste space by the inclusion of nonessential details is the best possible evidence that the subexecutive has an understanding of his work, has completely thought through and analyzed the situations that have confronted him, and in short, has successfully mastered his job and is the type of person to whom more responsibilities may be given.

Reports to executives should always be concise, should give the general facts and basic conclusions, if any, in the first few paragraphs, and then should follow them with such elaboration and data as are necessary in the particular case at hand. In a more comprehensive report, such as an economic survey, it is advisable to include *a summary and conclusion* as the first chapter of the report. This section is somewhat more condensed than the summary at the end of the report, but it should in-

clude the important conclusions. All information that is susceptible of comparative treatment should be so handled, so that the executive may see trends without having to look up previous reports or other older information. This comparison may be accomplished by the use of graphs or comparable statistical data. Statistical reports, to be effective in the development of system, must readily call the attention of the executive to unusual figures but should not draw his attention unduly to figures that may be considered normal.

Organization reports may be periodic or special. Special reports are prepared on some unusual subject by special assignment. Periodic reports are regularly presented at stated intervals.

Adequate records. System without records does not usually prove successful. Records are even more tangible than system. They are definite, and therefore their provision, maintenance, and improvement are relatively simple. Records should give the facts concerning the operation of the enterprise. Their preparation and use make possible the elimination of guesswork for management.

Good organization requires adequate records. Too few records are costly; too many records possibly even more so. Once the necessity for records is realized by those in charge of the enterprise, the immediate danger is the development of "red tape." "Red tape" is of three general kinds: (1) too many records, including some unnecessary ones and duplicates made up by different departments; (2) too many forms to secure essential information which might be obtained on a smaller number by combining several; (3) the unnecessary refinement of information. Ordinary processes of manufacture, distribution, or management may easily be halted to secure accurate figures when approximate information would serve the needs of the executive.

As previously stated, there should be as few separate forms as possible. A multiplicity of forms results in frequent loss and consequent absence of necessary information because one of many forms relating to a particular problem is not at hand. Forms should be of standard size wherever possible [8] in order that their handling, as well as their filing, may be expedited. They should be constructed so that they are read easily, with the most important information standing out most prominently when the form is filled in. An integral part of keeping adequate records is to maintain them so that they are readily available when needed.

One sound maxim concerning records, as well as other devices of *management,* is that *they are valuable only to the point where the cost of their collection is less than the savings which they will effect.* Many in-

[8] For example, 3×5, 4×6, 5×8, or $8\frac{1}{2} \times 11$ inches.

teresting data can be collected at large cost. If the executive is of the type who likes to know the detail of operations from every possible angle, it is not difficult for him to secure the information. It is likewise not difficult to increase the overhead cost of the business tremendously.[9] One type of records which usually justify its cost of collection, however large, is cost records, if their value is determined in broad rather than in narrow terms. Proper cost analysis gives invaluable data on conditions demanding reorganization and on the operation of the organization, as in results achieved through certain responsibility previously placed. The larger and more complex the organization, the greater is the importance of securing accurate cost records.

It is essential that all records, of whatever nature, be compiled so as to indicate trends. Records, like reports, which do not give comparative information frequently are valueless. Certainly the records that include comparative information are far more valuable than those that do not.

Operating rules and regulations. The third of the operating fundamentals of organization, rules and regulations, is the tie that binds together the other fundamentals. It defines the scope of the application of system to the various portions of the lines of authority which have been built up. It provides methods for the utilization of the records, and in innumerable ways it functions to knit the organization together into a unified whole. The establishment of exact rules, either verbal or written, facilitates the delegation of authority and responsibility and permits system actually to work, because *the superior and the subordinate both have a definite concept of their respective duties and responsibilities.* Written rules and regulations may be general in nature, touching only the broad outlines of business policy, or they may be more detailed, taking the form of a "standing order," which may provide the exact method of performance of nearly every task in the business. In developing rules and regulations, care must be taken to insure that they are amended as conditions change and that they are not so detailed as entirely to eliminate individual initiative and its good effects from the business. An operating manual exerts a stabilizing effect upon the organization and serves both as a guide to performance and a standard against which to measure accomplishment.

Rules and regulations include proper instruction of the personnel in all features of the business. Unless written rules are orally and intelligently interpreted at the time of their promulgation and the spirit behind them is clearly defined, it is likely that too often they will be observed

[9] The use of machine-kept records, especially the tabulating card, may simplify record keeping and greatly reduce the cost of compiling many details that would otherwise be almost impossible to accumulate.

to the letter in situations when the interpreter of all business regulations —judgment—should be exercised.

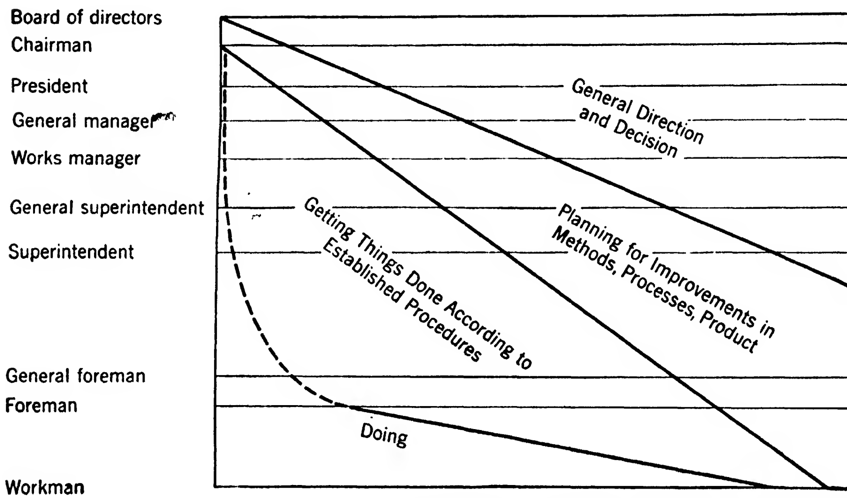
Effective leadership. The exercise of effective leadership provides the lubrication which makes possible the smooth functioning of the organization as a whole. The chief executive has three main tasks to perform: planning, organizing, and supervising. The operating executive spends most of his time in detailed planning to carry out the major plans of top management, organizing to effectuate the institutional objectives and exercising supervisory control over his subordinates. His organization task, although equally important, is not the one to which he devotes the majority of his working hours. The task of supervision or leadership consumes most of his time and consists, in the main, of making decisions and handling exceptional cases, as they arise, in a way that will promote the smooth operation of the organization. In carrying on this work, the executive, if he is capable, will at the same time provide inspirational leadership for his subordinates.

Frequently, in developing the responsibilities in his division of the business, an executive can find in his organization someone with qualities of leadership that can be exercised in a subordinate position. Successful enterprises usually have such men in their organizations. If such a man is properly placed in the organization, the other executives and subordinates will work harder, more whole-heartedly, and in a more sustained manner for the purpose at hand.

The so-called "strong man" is a man at or near the top who brushes aside the carefully developed lines of supervision or responsibilities which have been fixed and, through his own dynamic guidance, operates the organization or a large part of it. Such men are dangerous in long-enduring organizations because they tend to trample on the feelings and rights of others, destroy morale, and ordinarily, if they resign or die, cannot be replaced. However, when policies are being determined in new businesses, such a driving head is often superior, for purposes of getting an organization going, to a group of individuals without his driving power, even though they may work along theoretically correct lines of authority and responsibility. The combination of strong driving force from the top combined with observation of well-developed fundamentals of organization through the ranks is one of the best, if not the best, means of effective leadership that can be developed. Effective leadership implies the prior development of the primary fundamentals of organization. Without them, executive control involves one-man supervision of most of the details of a business, with all the attendant difficulties.

Poor leadership is easily observed; it is evident in the executive who is unable to get rid of the matters which come to him for decision, in the

man who makes snap judgments, in the man who shows his ignorance of the relationships of the various other phases of the business to his own, or in the man who treads solely the path of custom. The efficient executive plans the work for his subordinates, coordinates their efforts, and provides the dynamic leadership that inspires them to increased effort.



Courtesy, the American Management Association

FIG. 5.1. Chart illustrating the division of activities and responsibilities of officers, executives, and supervisors. (Adapted from American Management Association, *Personnel Series*, No. 24, p. 33.)

Figure 5.1 illustrates the division of activities and interests of officers executives, and supervisors in a given line of authority.

Standard instructions. Standard instructions are used to show the scope or lines of authority within the organization or to describe methods of procedure. A procedure involves the interrelationship of two or more persons in the business.

To use standard-practice instructions to show the scope of authority of each of the members of an organization makes these instructions interpreters of the organization chart, if there is one.[10] It is impracticable to show on the face of such a chart all the necessary facts. These standard-practice instructions are not necessarily fixed; in fact, it is usual to find them under constant revision. Their value is that during the periods of change existing relationships are maintained until they are superseded in written form by new information. The value of standard-practice

[10] See Chapter 6 for illustrations of the organization chart.

instructions, showing scope or lines of authority, is increased when functions are transferred from one member or department of the organization to another. They are of great value in bringing changed conditions to the attention of all persons within the organization.

To describe methods of procedure is the second reason for the preparation of standard-practice instructions. Examples might include instruc-

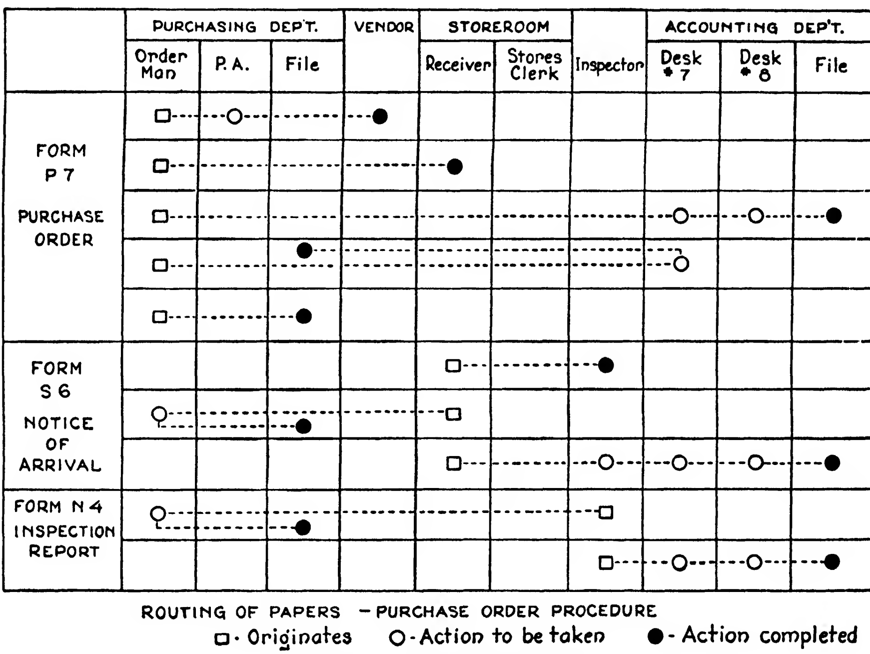


Fig. 5.2. A procedure chart.

tions concerning the handling of complaints, instructions concerning action to be taken on certain paper work, or instructions concerning the method of estimating the demand for a new article or line to be added to those already manufactured by the company. Such standard instructions clearly indicate the way in which successful management operates. When occasion arises for the development of such instructions, the manager in charge of the function involved sees that the standard instructions drawn up clearly indicate the procedure to be followed. Once this is done, the matter does not come to the executive's attention again until a change in the instructions becomes necessary.

Figure 5.2 indicates an effective way in which a procedure may be visualized through the use of a chart form of standard-practice instructions.

Advantages of standard instructions. Standard-practice instructions are advantageous and vitalize the development of the organization fundamentals within a business because:

1. They are not likely to be misunderstood.
2. They are less likely to be forgotten.
3. They fix responsibility for mistakes.
4. They clarify the ideas of those giving the orders and thus insure careful thought.
5. They encourage change in methods that should be continuously improving.
6. They expedite the routine to be followed by members of the organization.
7. They constitute a ready-reference file of executive decisions.

Reasons why standard-practice instructions sometimes fail. Standard-practice instructions have frequently failed in operation. Their failure can usually be ascribed to one of several causes:

1. Too many orders.
2. Not enough care in preparation.
3. Occasional delegation of the preparation of the instructions too far down in the organization.

Too many orders may be the result of one of two difficulties—either orders issued from too many sources, or too large a number of orders from one or more of these sources. Difficulty arises when two people issue orders on the same group of details or procedures. Nothing will break down the force of standard instructions more than to have two conflicting instructions, both supposed to be binding. The effect of too large a number of orders is almost equally bad. An order which is numbered, for instance, 546, is likely to be regarded lightly. The impossibility of keeping such a mass of instructions in mind is clearly evident to everyone. If it is necessary to revise order No. 36, it is desirable to call it order No. 36-A merely for the effect on the persons concerned.

The second chief reason for failure that must be guarded against when preparing standard-practice instructions is lack of sufficient care in preparation. Such lack of care may include either the use of terminology that is not clear or failure to visualize all the implications involved in the order being transmitted.

The third reason for failure of standard-practice instructions is that some person too far down in the organization scale is delegated to prepare them. This situation defeats much of the purpose of standard instructions, which is to insure at all times chief-executive direction, together with the operation of the exception principle.

CHAPTER 6

TYPES OF ORGANIZATION

Objectives of organization. The executive faced with the direction of the efforts of a number of people toward a common goal is forced to establish relationships among them. The structural relationships among the various factors of an enterprise contribute to the smooth functioning of the enterprise provided it is constructed along well-established principles. If fundamental principles of organization are violated, friction is certain to develop, morale is depressed, and the general effectiveness of the group is lowered.

One basic principle of organization is specialization of effort, or the grouping of related activities together. This is also known as the principle of functionalism.[1] (It should not be confused with Taylor's functional organization.)

Line, scalar, or military organization. Early industrial organization was usually of line, scalar, or military type;[2] that is, authority flowed directly from the boss to various subexecutives in charge of particular phases of the business and from them to other workers. In the simplest form of this military type of organization the boss was in direct authority over all the workers in the organization except certain of the factory workers who might be under a foreman. Figure 6.1 illustrates this organization.

There are two types of line organization: (1) pure and (2) departmental. Pure line organization is found only where the activities at any one level are the same, each man performing the same type of work, the divisions existing solely as a basis of control and direction. A group of one hundred house-to-house canvassers might be organized on this basis. In the departmental line organization the respective workers and supervisors are grouped on a functional basis, such as sales, manufacturing,

[1] A function is any activity that can be clearly differentiated from other activities. Functionalism in top organization consists in the dividing of the enterprise into its organic functions of finance, sales, manufacturing, and sometimes engineering and personnel. Each of these broad functions may be divided into many minor functions.

[2] "Military," as used in this chapter, has no connection with methods or organization in the army services today. It refers rather to the straight flow of authority within a single unit, sometimes called the scalar type.

engineering, and accounting. As industry grew in size, the military method of organization still continued predominant; and such changes as were made were brought about only by the growth in the size of the business and represented merely a delegation of authority over subordinates by the executives near the top in the business enterprise. This is illustrated in Figure 6.2.

Line organization is direct, and the members know to whom they are accountable; it is simple and easily understood, flexible and able to be expanded or contracted readily, strong in discipline through the fixing of responsibility, and capable of developing the all-round executive at the

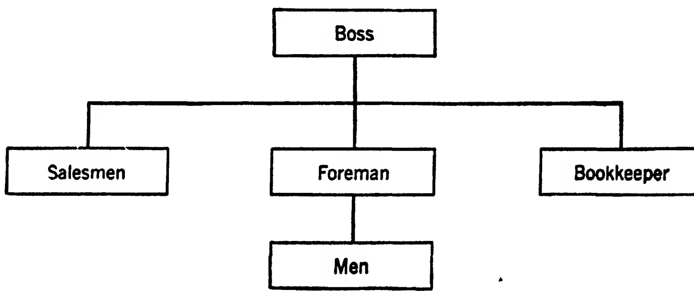


FIG. 6.1. Simple line organization for a very small enterprise.

higher levels of authority. On the other hand, the line organization overloads a few key executives, encounters difficulty in getting the executives at the lower levels to grasp the need for coordination, makes little use of the principle of specialization, and requires a high type of supervisory personnel to carry the burdens imposed in the absence of specialists as advisers.

If a strong man capable of carrying the load is available, at times when competition is keenest it may be desirable to fix responsibility for a department entirely on one man and to allow him to develop a strictly military type of organization within his department, so that results may be prompt, and responsibility for them may be fixed exactly. Military organizations can have their heads changed more readily, little coordination being needed within them, since responsibility rests clearly at the top. It is perfectly possible to develop some departments on a line-and-staff basis and others, where suitable conditions exist, on a military basis, in order to secure the advantages of both types of organization.

Functional organization. The difficulty encountered in finding foremen who could carry the burdens of supervision in the strictly line organization led Frederick W. Taylor to seek a new organization structure. His solution was the division of responsibilities among different men who

were especially qualified for their special functions. He replaced the general foreman with four functionalized foremen.

In setting forth his plan, Taylor said, "It is because of the difficulty—almost the impossibility—of getting suitable foremen and gang bosses, more than for any other reason, that we so seldom hear of a miscellaneous

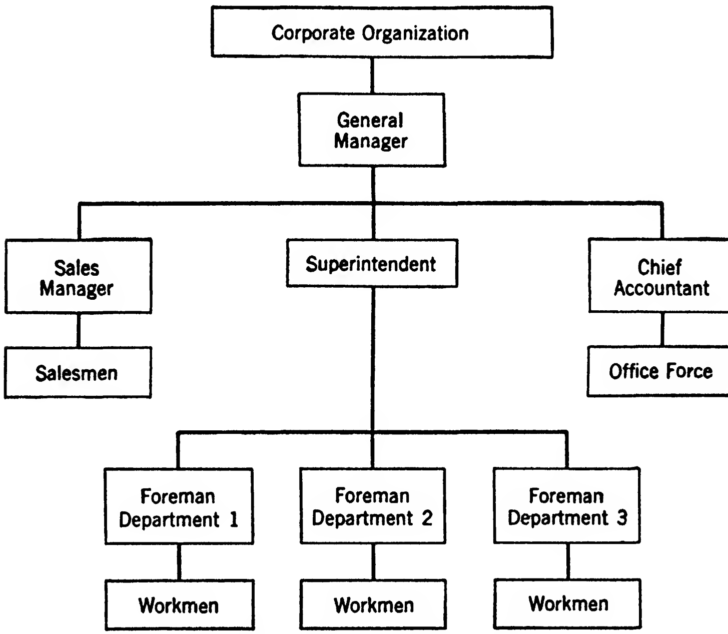


FIG. 6.2. Line organization chart.

machine works starting out on a large scale and meeting much, if any, success for the first few years." He further stated:

> This difficulty is not fully realized by the managers of old and well-established companies, since their superintendents and assistants have grown up with the business, and have been gradually worked into and fitted for their especial duties throughout years of training and the process of natural selection. Even in these establishments, however, this difficulty has impressed itself upon the managers so forcibly that most of them have of late years spent thousands of dollars in regrouping their machine tools for the purpose of making their foremanship more effective. The planers have been placed in one group, slotters in another, lathes in another, etc., so as to demand a smaller range of experience and less diversity of knowledge from their respective foremen.[3]

[3] Frederick W. Taylor, *Shop Management,* Harper and Brothers, New York, 1911, p. 93.

Despite this effort to meet the situation by regrouping of machines, it nevertheless was found practically impossible for a new establishment to secure suitable superintendents and foremen of the business organized along the lines of the military plan. The regrouping of machines (functional layout) was a mistake in many plants, because the manufacturing process could be carried on better with the original layout of machines.

Under the military type of organization the foreman is held responsible for the successful running of the entire department; and, when his duties are measured by the requirements of good management, it becomes apparent that these requisites are extremely difficult to meet under the conditions. The foreman under this system of organization must lay out the work for the whole department, seeing that each piece goes in its proper order to the right machine, that there is a man at the machine to do the job when it gets there, and that he knows just what is to be done and how he is to do it. The foreman must see that the work is done correctly, is not slighted, and is done promptly. Meanwhile he must look well ahead, possibly a month or so, to determine what the demands on his shop will be at that time. He may have to provide more men to do the work, or he may have to try to secure more work for the men to do. The disciplining of the men is entirely the responsibility of the foreman, as are all relationships between the firm and the men on the subject of wages, including the supervision of timekeeping, the fixing or recommending of piece rates or day rates, and the readjustment of these from time to time.

It has been seen that, in order to have good organization, responsibilities must be fixed; that is, each member of an organization must have a clearly defined task, the limits of which are well known. It is evident that there are few limits to the foreman's task under military organization and it is unlikely that the task can even be defined. Each day he must decide, on the basis of his own judgment, just what small part of the mass of duties in front of him it is most important for him to attend to. He does a fraction of the work for which he is responsible, leaving the rest to gang bosses and workmen to do as they may see fit.

Taylor pointed out that the qualities of a well-grounded man are as follows: "brains, education; special or technical knowledge; manual dexterity or strength; tact; energy; grit; honesty; judgment or common sense; good health." He believed that a man with three of these qualities could be hired at any time for laborer's wages. If four were required, it was necessary to secure a higher-priced man. The man combining five of the qualities was hard to find, and the one with six, seven, or eight almost impossible to discover.

Functional shop supervision. Taylor believed that the solution to the problem lay in functional shop supervision, as outlined in Fig. 6.3. He

felt that functional foremen, each with but one type of task, would need but four or five of the attributes which he had outlined and that such men could be found. Under functional foremanship each workman, instead of coming into direct contact with but one supervisor, would receive his orders from a group of specialized supervisors, each of whom performed a particular function. Because of this feature, functional foremanship was never generally adopted, although the development of staff or functional departments to deal with particular phases of the business and to relieve general supervisors of these phases was a direct outgrowth of the problems of military foremanship, as influenced by Taylor's functional idea. In *Shop Management* Taylor set down the proper number

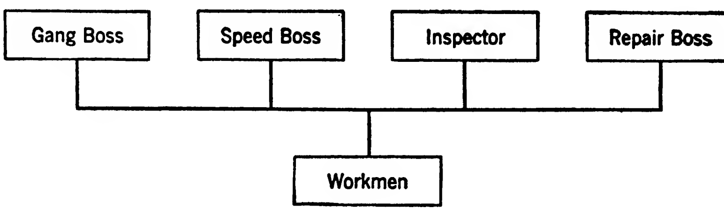


FIG. 6.3. Functional organization chart, showing Taylor's shop bosses.

of functionalized foremen as eight, four of whom were engaged in general planning work and thus were entirely removed from the shop. These four were really not foremen at all, but staff men working in a production-planning office. "These four representatives of the planning department are, the (1) order of work or route clerk, (2) instruction card clerk, (3) time and cost clerk, and (4) shop disciplinarian."[4]

The four foremen in the shop were to help the men personally in their work, each boss assisting only in his particular function. Some of these bosses came into contact with each man only once or twice a day, and then for only a few minutes, whereas the others were with the men constantly and helped each man frequently. There was no specific group of workmen with the same four bosses over them, but rather a number of workmen, falling into varying groups for supervision purposes but organized into given departments for production purposes.

The following brief description of the work of the Taylor "executive functional bosses" will also serve as a guide to possible division of work between line foremen and staff departments in line-and-staff organizations.

[4] *Ibid.*, p. 102. It will be well for the student to recall that the modern cost department is the successor to Taylor's cost clerk, and that the present personnel department is the outgrowth of the shop disciplinarian.

The gang boss has charge of the preparation of all work up to the time that the piece is set in the machine. It is his duty to follow up the plans of the planning men and to furnish all the jigs, templets, sling chains, and other necessary adjuncts for coming operations. The gang boss must show his men how to set their work in their machines in the quickest time and see that they do it. He is responsible for the work being accurately and quickly set and should be not only able but willing to show the men how to set the work in proper time. This man has nothing whatsoever to do with the running of the machines, and his job on a particular operation is completed when the work is set up in the machine.

The speed boss must see that the proper cutting tools are used for each piece of work, that the cuts are started in the right part of the piece, and that the best speeds and feeds and depth of cut are used. His work begins only after the piece is set up in the machine and ends when the actual machining ends. The speed boss must not only advise his men how best to do the work, but also he must see that they do it in the quickest time, and that they use the proper speeds of the machine and so set their tool that they secure the proper depth of cut. By the exigencies of a situation he may be called upon to demonstrate that the work can be done in the specified time, by doing it himself in the presence of his men. The words "speed boss" refer to supervision over proper speed and not to an attempt to "speed up" the workman without regard to his capacities or the time in which the operation should be performed. This man has recently been termed an "instructor" rather than a "speed boss."

The inspector is the third of the shop bosses and is responsible for the quality of the work. Both the workman and the speed bosses must see that the completed work is up to specifications in order that it may be passed for quality by the inspector. The inspector can, of course, best qualify for his tasks if he is complete master of the machines himself and can personally do the work both quickly and well. Under such circumstances his rejections will be taken with better grace by both the workmen and the other bosses in the shop. The inspector always sees that the first piece made up is of the proper standard in dimensions, fit, and finish. He also makes further inspection from time to time, as the needs of the job may dictate, to see that the standard is maintained.

The repair boss is the fourth and last of the shop foremen. The duties of the repair boss include seeing that the workman maintains his machine and work place in proper condition. This maintenance includes cleaning the machine, keeping it free from rust and scratches, oiling it properly, and preserving the standards which have been set up for the auxiliary

equipment connected with the machine, such as belts, countershafts, and clutches. Keeping the floor around the machine clean is also a task under the supervision of the repair boss.[5]

Can a workman serve two masters? There is a very deep-rooted conviction in the minds of many industrial managers that no man can work under two bosses at the same time, and for this reason the idea of functional foremanship had slow growth in comparison to other modern management devices. The thought that a workman could not serve two masters prevailed, and today we find, not functional foremen, but rather functionalized staff departments, working through one foreman.

In summarizing Taylor's idea of functional supervision the advantages may be listed as follows:

1. Specialized skills are brought to the individual workmen.
2. It is possible to find supervisors in sufficient numbers who possess the required abilities.
3. The separation of manual from mental work takes advantage of the principle of specialization.

The major disadvantages of functional organization are:

1. It tends to complicate problems of discipline among the lower levels of the organization.
2. Coordination of the efforts of the various functional foremen is difficult. (Among major executives this is not so great a problem.)
3. Such organization tends to narrow specialization among executives and workers.

Line-and-staff organization. This type of organization adds to the direct "line" flow of authority provided in the military type functionalized "staff" departments, which deal with one particular phase of the business. Figure 6.4 shows a simple development of line and staff in the production and sales departments of a business. The functions marked "X" are staff.

In the manufacturing division of a business, the functional departments guide and to some extent control the foremen. In their development it is assumed that the foremen are intelligent, in fact, that they are the backbone of the operating organization of any plant. The organization is so constructed that the foreman can retain his one-man control over the personnel under him and at the same time can have his direct responsibilities reduced to a point within the range of accomplishment. The foreman's primary duty is leadership, and under this plan of organization he can better perform this function. The functionalized staff depart-

[5] Much of the material in the preceding paragraphs is adapted, by permission, from *Shop Management*, by Frederick W. Taylor, Harper and Brothers.

ments give technical operating information and orders to those in direct charge of the workmen.

In the sales division of a business the functional departments do not direct the operating or line activities in any way but perform some specific function, such as advertising, which is of direct assistance to the line members of the organization in better performing their duties. Functional departments have this same position in the financial division also.

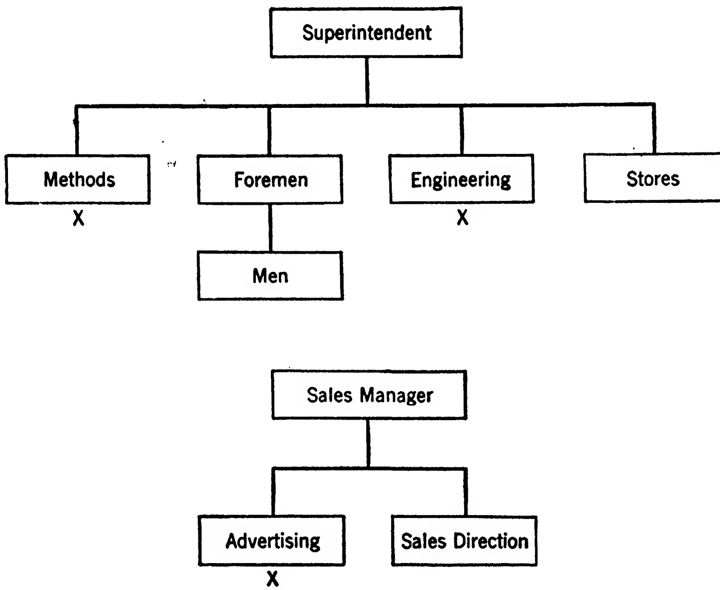


FIG. 6.4. Line-and-staff organization.

The distinction between line and staff members of a complicated organization is not always clear. In any case, in an operating organization it is more important that the line-and-staff idea be utilized in the setup of the organization than it is that each individual's duties be clearly line or clearly staff. It is probable that many persons will have their duties develop so that they will be in some respects line and in other respects staff. A line man, however, usually controls more than one particular function of the business and has under him workers who are directly productive.[6] A staff man usually controls but one function of the business, and workers who are directly productive do not ordinarily report to him. Departments are line or staff, as their heads fit into one

[6] "Productive" is here used in its popular sense of referring to work that is directly associated with turning out the product. Strictly speaking, all work should be productive or else eliminated.

or the other of these categories. It may well be observed, however, that a staff department may itself be organized on a line basis. The accounting department, personnel department, and methods department are functional staff departments, which render a service to the main productive unit of the enterprise.

The line-and-staff organization has practically all the advantages of both the military and functional organizations with relatively few of their disadvantages. At times the staff department may infringe upon the rights and responsibilities of the line organization, thus weakening the line organization when its true function is to strengthen this organization.[7]

The staff officer. Usually the staff officer has no administrative authority whatsoever but is an expert in some phase of the operations; he reports to an executive and gives advice on the subject of his specialty. This specialty may be general administration, if the staff officer is an assistant to the president or an assistant to the general manager; or it may be statistics, finance, budgeting, law, or innumerable other fields. Sometimes, for instance, in legal advice or budgeting, the work may be sufficiently heavy to permit the development of a staff department instead of an individual. The great advantage of the addition of advisory free lances to an organization is that they are altogether free of administrative or managerial duties and hence are able to devote all their time to work in the field of their specialty.

The committee. The cooperation of the men forming the organization is essential. To enlist the cooperation of these men, on whom in the last analysis the success of the operation depends, is, in its larger elements, not a really difficult task. They must have some share in forming the plans, some share in devising the methods of management. They must be made to feel that the methods being utilized are really their own. They must be consulted frequently and thoroughly concerning difficulties and encouraged to suggest ways of overcoming them. It is their knowledge, their experience, and their information about detail which must be brought to the aid of the developers of management methods.

All plans dealing with organization, reorganization, or operation of a business which are formulated by the heads of the enterprise must necessarily be constructed with three cardinal principles of cooperation in mind:

[7] See William R. Spriegel and Ernest C. Davies, *Principles of Business Organization*, Prentice Hall, Inc., New York, 1946, pp. 47–69, for a detailed discussion of the advantages and disadvantages of the various types of organizations and of the committee.

1. Consideration for the viewpoint of those persons who must execute the plan.
2. Persons close to the details of operations may contribute constructive suggestions.
3. Plans will be more effectively executed when the participants thoroughly understand all the causal relationships and factors involved.

Plans should be developed along the lines of complete coordination. Generally the joint advice of a group of men conversant with a subject is immeasurably superior to the ideas of one man or to any plan developed from a single individual's brain. The best method of developing a proper group spirit is to get men together. Their jealousies and their distrust of each other can be eliminated only by bringing them into close contact with one another and by steering them in a tactful manner. The spirit of helping each other for the good of the enterprise can best be developed in a conference. The results may be gradual, but, if proper attention is paid to the methods of cultivation, they will not be difficult to secure.

The committee recognizes the human factor, fosters the spirit of co-operation, implants the new ideas of organization and its fundamentals in the minds of all members of the organization, and gives everyone the contacts necessary to perform his tasks properly. On troublesome problems the committee secures the advice of those best qualified to aid. It stimulates these men to give the company the best that is in them. The standing committees solve routine problems of operation but also investigate and advise concerning policy and organization development.

Committees, largely advisory, are used extensively in organization today. They usually suggest courses of action to the chairman, aiding him in reaching the decisions for which he is held responsible. He may accept or reject these recommendations, but normally, if the committee work is properly developed, matters will be thrashed out there and the decision reached will be practically final.

There are four general types of committees in use in industry:

1. The committee which has full power to act. (Seldom found save at the top management level.)
2. The committee which has limited power but whose actions are subject to veto. (Not used extensively.)
3. The advisory committee.
4. The educational committee, the class or discussion group.

The committee is a weak control device and a poor substitute for proper organization in the first place. Most committees with authority incorporate an element of compromise which frequently does not represent the true facts of a situation except in the case of policy determination. Unless committees are used wisely, they tend to waste the time of the members. Committees are of great value as a means of coordinat-

ing the efforts of the departments which are represented. They are also of special value in broad policy determination.

As a rule a committee is not well adapted to the collection of facts or technical data. A member of the committee or an expert under the direction of the committee may collect the facts, and the committee may evaluate them or formulate a policy supported by them. Such a policy is likely to be more inclusive and to consider the broader implications than a policy that is the work of a single individual.

The manufacturing advisory committee. The tentative personnel for the manufacturing advisory committee would include the *product engineer;* the *sales manager,* or the member of the production organization whose function is to effect liaison with the sales organization; the *head of the cost department;* the *general superintendent;* the *purchasing agent,* if purchasing is a major item; as well as the *director of manufacture,* who would preside over the committee's deliberations. Other men may be added to the committee when special items are considered. The production manager should sit in on the discussion of production schedules.[8] The director of personnel often is a member of this committee, as is the plant engineer if plant changes are being considered. The representative of the sales department need not sit in on the meetings of this committee where matters are being considered that do not directly affect sales. Other members of this committee need not attend its meetings when special items in which they are not interested are the major factors for consideration. A copy of the minutes, however, should go to every member of the committee. The secretary should not only preserve information concerning actions taken but also should straighten out many difficulties between meetings and have matters for the committee's attention in such shape that it will be possible to get them out of the way in minimum time at the meetings.[9]

The work of the committee can usually include:

1. Plans to change the product, including a consideration of new methods of design or new items to be marketed. The interplay of sales and production factors must be considered here.

2. Progress that has been made on changes already begun. This is important, for otherwise it will be found that new ideas which have been decided upon and partially put into effect can be totally forgotten in the press of daily routine.

[8] In fact, he is frequently a permanent member of the committee and often serves as its secretary.

[9] See Paul E. Holden, Lounsbury S. Fish, and Hubert L. Smith, *Top-Management Organization and Control,* Stanford University Press, Stanford University, 1941, pp. 59–73, for an excellent discussion of the uses and limitations of the committee. Every executive who uses a committee should read this section of the book.

3. Consideration of methods of cost reduction. Reports by committee members upon economies, decided upon in previous meetings, and assigned to them to put into effect, might be included. In this connection, when work of a specific department is taken up, it is possible and advisable to have the foreman in charge of that department in the committee meeting, whether or not he is regularly a member of the committee.

4. Coordination. A discussion of routine operation, the status of orders, causes of hold-ups, progress of manufacturing programs, and similar subjects.

The number of meetings of this main committee or any other committee should be determined by the needs of the business. However, there probably should be at least one meeting a week.

Foremen's meetings. It is desirable to have a general meeting of the foremen about once a month. It is necessary to guard against having one man at too many meetings, however, lest his time be taken up entirely with the discussion of what he is to do and what he has done, and he be not given the opportunity really to do anything. At this foremen's meeting there should be present the foremen and assistant foremen, the members of the Plant Advisory Committee, including the superintendent, and, if possible, one of the higher officials of the company.

At these meetings operation problems are the main basis of discussion. Employment and general labor matters are also important subjects. Frequently the labor policy of the enterprise can be so shaped at the foremen's meetings as to eliminate danger of labor troubles.

If the departments in a concern are not too numerous, each foreman should make a statement concerning the status of his own department and a statement as to whether any other department is causing him or his men any difficulty of any kind.[10] As the foremen know that they cannot deceive the other foremen, each of whom will naturally defend the work of his own department, such a system leads to the discovery of many causes of retarded production. The ensuing discussion leads to definite plans for the overcoming of these difficulties.

In large manufacturing enterprises having a hundred or more foremen the meetings will probably have to be held on a divisional basis. Even in such plants it is profitable to have from four to eight evening meetings during the year attended by the entire group of foremen. These meetings may well be both educational and operational in nature.

Organization charts. Organization charts portray the structure of the organization by indicating positions or departments and then showing the lines of supervision between them, as well as frequently stating definitely under each position or department the responsibilities attached to it.

[10] See C. W. Mason and Glen U. Cleeton, American Management Association, *Personnel*, Vol. 15, No. 3, February, 1939, pp. 144–148, for an excellent discussion of the techniques of the conference method of conducting meetings.

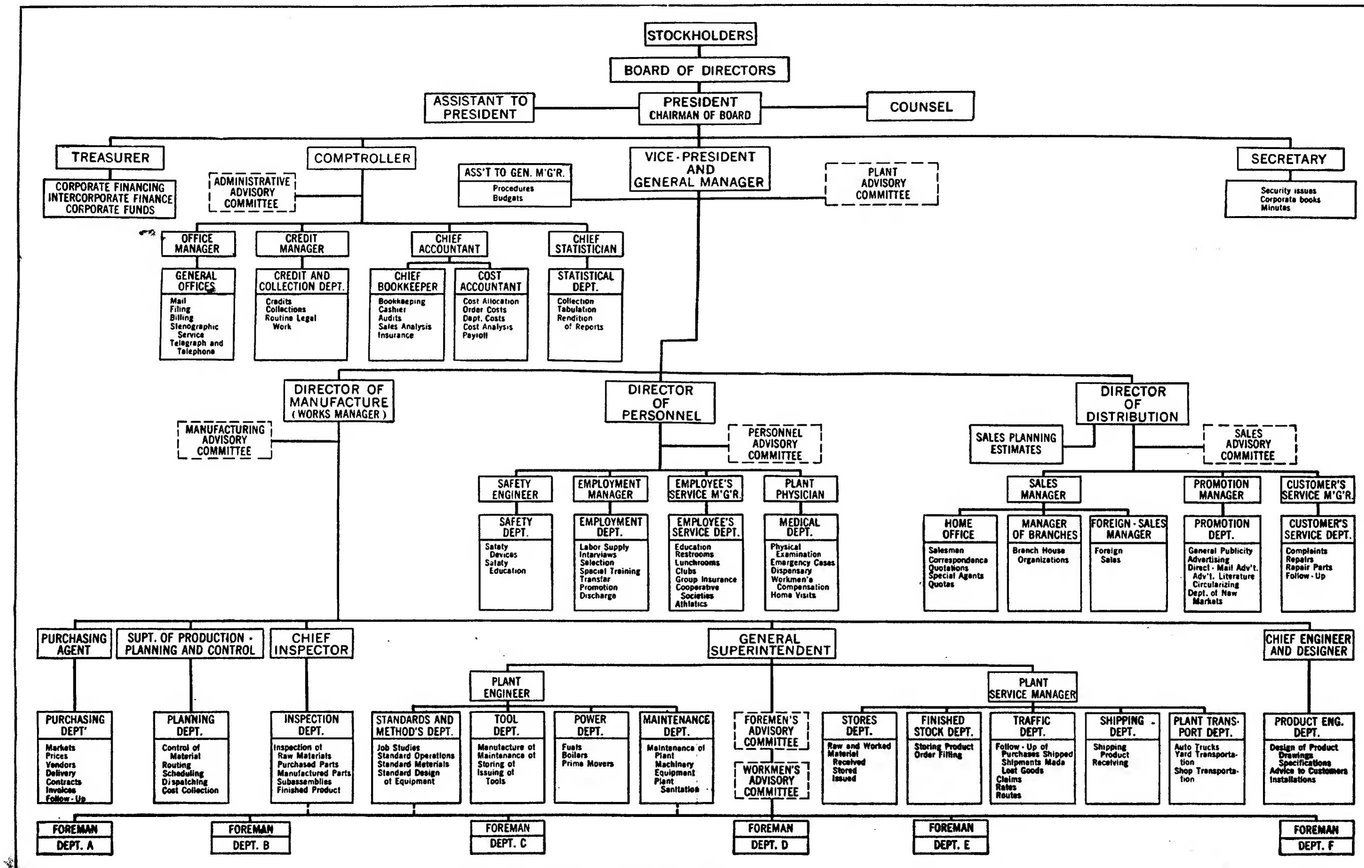


FIG. 6.5. An illustrative organization chart of a manufacturing corporation.

Organization charts, like other diagrams, are not wholly satisfactory, inasmuch as many little details and interrelationships of live, operating organizations cannot be pictured properly on a chart. The most satisfactory way of studying modern organization development, however, is through the utilization of a typical organization chart. In studying such a chart it is well to remember that the titles given individuals or departments in various enterprises vary with the whims of the organizer, even though the duties performed may be essentially similar. Figure 6.5 indicates the organization of a relatively large enterprise, showing the various functional departments. It should be clearly understood that in small concerns, although the same functions may exist, many duties will have to be combined. The gigantic corporation, such as General Motors (Fig. 6.6), has a more complicated organization in the upper brackets than that illustrated in Fig. 6.5. This complexity is made necessary by the problems of coordinating the activities of the various divisions, each of which is a large enterprise by itself.

It would be claiming too much to say that Fig. 6.5 is a typical organization chart, but it is illustrative of many organizations. In practice there are innumerable exceptions to the exact positions of various departments assigned in Fig. 6.5. Where product engineering is highly technical or the style element is of special importance, the product engineer often reports to the vice-president and general manager. It is not at all unusual to have a plant engineer reporting to the general superintendent or the director of manufacture. In such cases the power department and the maintenance department report to the plant engineer. Other exceptions will be pointed out in later discussions.

An illustrative organization. All organizations have at the top the owner or owners of the business—an individual, partners, or a group of stockholders in a corporation. In studying organization it will be best to consider the most complex of these businesses and the one most typical of our present economic life, that is, a corporation owned by stockholders. In such a business the distinction between the corporate or ownership activities and the operating activities is ordinarily clear-cut. The stockholders usually select, through their elected board of directors, a president who is actively engaged in the direction of the corporate policy of the business (Fig. 6.5). The president supervises all the truly corporate activities of the business but ordinarily does not supervise the operating activities except in a relatively small organization. In carrying on his work, the president is assisted by duly selected officers having control of certain parts of the corporate work, such as the treasurer, in charge of company funds and financial policy, and the secretary, in charge of corporate records and stock transfer. The functions of the treasurer and

secretary should not be confused with somewhat similar ones incident to the daily operation of the business. In the type of organization being described, these latter functions would be controlled by executives reporting to the president or general manager, who has charge of the operation of the business. In many smaller concerns there is no president, but instead a general manager who reports directly to the board of directors, or the president and general manager may be the same person. In such organizations the treasurer is in charge of the operating details of his division as well as the corporate work. Thus routine accounting and record work would be under the control of the treasurer. It is usual to have the secretary of the company keep only the corporate records, regardless of the organization; in the small corporation, however, one person may be both secretary and treasurer.

Divisions of an industrial enterprise. Under the president, general manager, or operating head of the enterprise, there is an immediate split into divisions [11] of operation, functional in form. There is, for instance, the *comptroller,* who deals with all office, accounting, and record operations; the *manager,* or *director of manufacture,* who has under his control all matters relating to plant operation and the manufacture of products; the *director* or *manager of distribution,* who controls sales; and, in many modern organizations, the *director of industrial relations,* who deals with all matters concerning personnel. In this development of the main operating organization it will be noted that there are but a small number of main divisions, which means that only a few persons report directly to the chief executive. This is an essential of good organization. It gives the general manager an opportunity for real policy development, which he does not have if a large number of persons are reporting directly to him.

A necessity which is often overlooked is that of sometimes creating special temporary divisions for carrying on some unusual work. Examples can be found in the creation of a "new building" division if a new structure is being erected for the business, this division having supervision over construction and movement into the new building; or in the creation of a "government work" division when government contracts are held by the business.

The comptroller's division. The comptroller (or treasurer in the smaller organization) has under him certain staff heads, each control-

[11] The terms "department" and "division" are frequently used interchangeably. When a distinction is made, "division" should represent the larger unit. For instance, either the manufacturing or sales division may have several departments. The word "division" is also used to represent a spatial or geographical unit of an organization.

ling the operation of one phase of the office work. These men are the office manager, in charge of the general office operation; the credit manager, in charge of the granting of credits and the collection of accounts receivable; the chief accountant; and the chief statistician. A separate section is set up under the chief accountant to handle costs. (This is a particularly important phase of manufacturing accounting. The collection of cost information is often regarded as a production function and may be placed in the hands of the planning department, under the production manager.) There must of necessity be some tie-up between the distribution division and the credit man under the comptroller. By placing on the credit committee a representative of the sales department, such a tie-up can well be secured.

A few organization specialists advocate having the comptroller report directly to the chairman of the board of directors, thus giving the board an independent check on operations. In such cases the comptroller will only have the accounting section under his supervision. This independence of the comptroller has some merit in theory, but it is of questionable value from an organization standpoint.

The sales division. The work of the director of distribution falls under several heads, each of which in large organizations is in charge of a competent executive. Thus there is the function of promotion, including advertising and the development of new markets, sales, and service after sales. The organization of the office of the director of distribution will be found to vary considerably with the selling problems involved in different types of enterprises. Where advertising is the major factor in selling, as in tooth-paste industries, the advertising division may not be under sales promotion but instead may report as a special section to the director of distribution, also known as the sales manager.

The personnel division. The work of the director of personnel has increased largely both in amount and in responsibility during the past twenty-five years. In its full development it has jurisdiction over all matters pertaining to the personnel of the organization, be that personnel in the comptroller's office, in the sales division, or in the manufacturing division. In a well-developed program the director of personnel (often called director of industrial relations) reports to a major executive, such as the president or executive vice-president or works manager. His position should be on the same level as that of the factory manager.[12] In a substantial number of cases, however, the director of personnel reports to the factory manager, since his division has quantitatively the largest amount of personnel work to do. This arrangement may be

[12] See Holden, Fish, and Smith, *op. cit.*, pp. 38, 40, 45–48.

satisfactory if all members of the organization understand the true function of the personnel department, but frequently it handicaps the work of the department. From the standpoint of experience and qualifications the director of personnel in a medium-sized plant or larger should be in every respect as capable as the man in direct charge of manufacturing. See Fig. 40.1 for an illustration of the organization of the personnel department of a large electric manufacturing organization.

The manufacturing division. Immediately under the director of manufacturing, or the "works manager," as he is frequently known, is the superintendent (Fig. 6.5), who, with the aid of advisory committees, directly controls the operations of the foremen[13] of the various departments of the factory. The foremen are directly over the workmen, possibly through job bosses, or assistant foremen, who may be in control of certain portions of their department. There is thus direct line control or authority from the director of manufacturing to the workman. It is the establishment of this authority which promotes discipline and allows for the quick and accurate working of the organization.[14]

The staff portion of the manufacturing organization may be found partially under the direct supervision of the superintendent. The manufacturing division affords the best opportunity to observe the effect of the functional idea in the development of the staff portion of the "line-and-staff" organization. First, the purchasing agent is in charge of the purchasing department. Under many of the older types of organization this position was ordinarily placed on an equal plane with that of the chief of manufacture. In modern organizations the purchasing agent is sometimes found in the same position. Making purchasing a main division of the business may result from consideration of the personal equation, but it is generally due to the importance of purchasing in the particular business. Such correlation with other departments as is necessary can be secured through placing the purchasing agent on one or more advisory committees and still leaving him under the control of the manufacturing manager. The value of placing the purchasing agent under the

[13] The term "foreman" is used rather loosely in industry. One company uses the hierarchy of supervision as follows: superintendent (of a division or branch), assistant superintendent, general foreman, foreman, assistant foreman, section chief, group chief (the lowest level of supervision). Another company of equal size calls its lowest level of supervision "foreman." The general foreman in the first company occupies about the same position as the superintendent in the second company. Other companies' terms, such as "supervisor" and "job master," designate their foremen. A foreman in one plant may be responsible for more men than a general superintendent in another plant.

[14] Compare Fig. 6.5, illustrating a complete organization, with Fig. 6.7, the Buick Motor Division of General Motors.

control of the director of manufacture lies in the correlation thereby secured of his functions with those of the production manager, inspector, and chief engineer. The work of each of these men is bound up closely with the operations of the purchasing agent.

The chief engineer usually has charge of the design of the product, some or all of the equipment used in its manufacture, and related subjects. He is thus particularly qualified to sit on several of the important committees and it is necessary that he should, since his work affects nearly all phases of the business. He is usually a member of the Manufacturing Advisory Committee, and frequently he may be found on the Plant Advisory Committee. It is ordinarily a mistake to make the engineering or design department a separate division of the business, reporting directly to the general manager. This arrangement tends to lay too much emphasis on changes of design of product, with the result that both sales and production departments are hampered in their operation. However, there are some businesses, such as clothing manufacture and the automobile industry, where the designer is of great importance, and in such cases the chief design engineer may well head a separate division reporting directly to the president or general manager. The production manager has charge of those features involved in aiding smooth flow of production.[15] The chief inspector has charge of measuring and maintaining the quality of the product.

Under the superintendent in the factory organization are found the departments which deal with particular functions of plant operation. The plant service manager has charge of the functions which primarily assist the other departments dealing with production to operate smoothly. In some organizations the purchasing department, stores department, finished-stock department, shipping department, and transportation department report to the production manager (often called the manager of production control). This is a logical arrangement, since he is in the best position to issue orders to them. On the other hand, in such instances he is responsible for the operation of a substantial number of workmen, and this function calls for qualities somewhat different from those needed for planning and scheduling, which are the primary activities in most production-control departments.

The planning department has complete jurisdiction over all the planning functions handled by the foremen under a strictly military organ-

[15] The production manager in some organizations has charge of the standards and methods department, the tool department, the power department, and the maintenance group. To supervise these departments he must be an executive of high caliber, not just a clerical specialist. The exact location of these departments depends largely upon their relative importance and personalities.

ization, and in addition its development has caused the creation of certain new functions, as enumerated. The standards and methods department is interested in investigating and explaining how the work should be done, in order that the planning department may have a basis on which to plan, and the foreman on which to direct. It also provides the inspectors with a basis on which to check the work. The tool department insures that all tools of any kind that are necessary to production are ready at the time needed and in proper condition. Thus maintenance of tools is part of the work of the tool department rather than the maintenance department. The power department has charge of the generation and transmission of power throughout the factory. The maintenance department is responsible for the maintenance of plant, machinery, and equipment and is the logical outgrowth and development of the "repair boss" under the original scheme of functionalized shop supervision.

The functionalized inspection department under the chief inspector is the quality department of the manufacturing organization. It is especially desirable to have different men working for quantity and quality. At the same time their work must be correlated. In industries in which the quality of the product is not of major importance, the inspection department may report to the superintendent.

The safety engineer has complete charge of all safety work in the factory. His position is one of great importance. As a matter of fact, in hazardous manufacturing he may become a man of such importance as to be called director of safety and to be one of the men immediately under the general manager.

The plant service manager has charge of the stores department, finished-stock department, traffic department, shipping department, and plant-transportation department. In order to be able to control the planning elements of production, it is essential for the production manager to have close contact with the plant-service manager and the operation of the stores department. The work of the other departments under the plant-service manager is self-explanatory, except that it will be noted that follow-up of purchases shipped and of finished goods shipped is often left with this group rather than with the purchasing and sales departments, respectively. (See Fig. 6.7, the Buick Motor Company, for another arrangement of these functions.)

Organization chart of the General Motors Corporation. Few organizations indeed have taken the stockholders and the public more into their confidence than the General Motors Corporation, whose avowed policy is to make known in published form the principles and policies governing operation. Figure 6.6 illustrates their corporate organization and the relationship of the various divisions to the central organization. For many

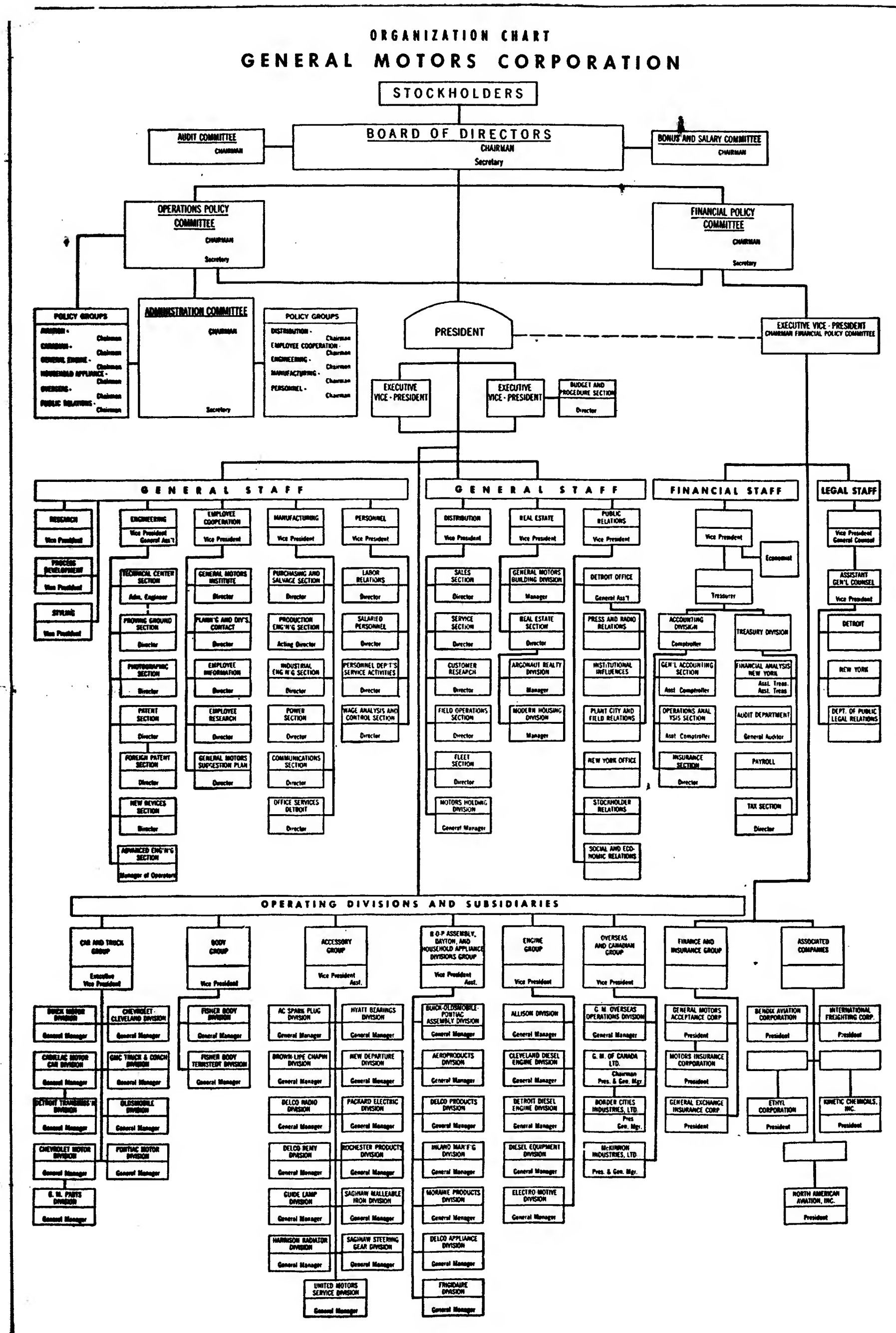


FIG. 6.6. Organization of General Motors Corporation.

years one of the basic policies of the corporation has been "decentralized responsibility with coordinated control." In studying this organization chart the student should keep in mind the fact that each of the "operating divisions" is a mass-production unit within itself and bigger by far than most large-scale industries. Of necessity the organization of such an enterprise is more complex than that of a smaller business. For instance, the Car and Truck Division has an executive vice-president of the entire corporation in charge. Each of the main automobile companies has a general manager whose position, from the standpoint of the individual automobile plant, is equivalent to that of the president of an independent plant[16] (Fig. 6.7).

The organization chart of the Buick Motor Division. The Buick Motor Division organization chart (Fig. 6.7) should be analyzed in connection with the organization of the parent corporation. For instance, in the parent organization under the manufacturing vice-president there is a purchasing and salvage section, and the Buick Motor Division also has a purchasing agent. The purchasing section of the parent organization buys certain items that may be purchased more advantageously by the central organization, and the Buick purchasing agent purchases items that can best be purchased direct. The functions of both purchasing groups are large-scale. The chief engineer reports directly to the general manager, whereas the "general works engineer" and the "general master mechanic" report to the assistant general manufacturing manager.

United States Rubber Company. Figure 6.8 shows an interesting chart of the administrative organization of the United States Rubber Company. This chart is worthy of close study in connection with auxiliary departments.

Oliver Machinery Company. Figure 6.9 illustrates the organizational structure of a closely held corporation whose major officers are also members of the board of directors of the corporation and its controlling stockholders. Although this enterprise is corporate in structure, it actually functions very much as a partnership might function, each officer discharging the responsibilities for which he is best suited without regard to conventional relationships or individual factory departmentalization. It works because of a high degree of cooperation between the officers of the company. The president, a graduate engineer, is works manager for all three plants, and is in direct charge of Plant No. 1, supervises costs for Plant No. 1 and to some extent for Plant No. 2, and together with other officers supervises designing. The vice-president, also a graduate engineer, is manager of Plant No. 3, supervises the production schedule

[16] See Appendix A for an explanation of the General Motors organization chart.

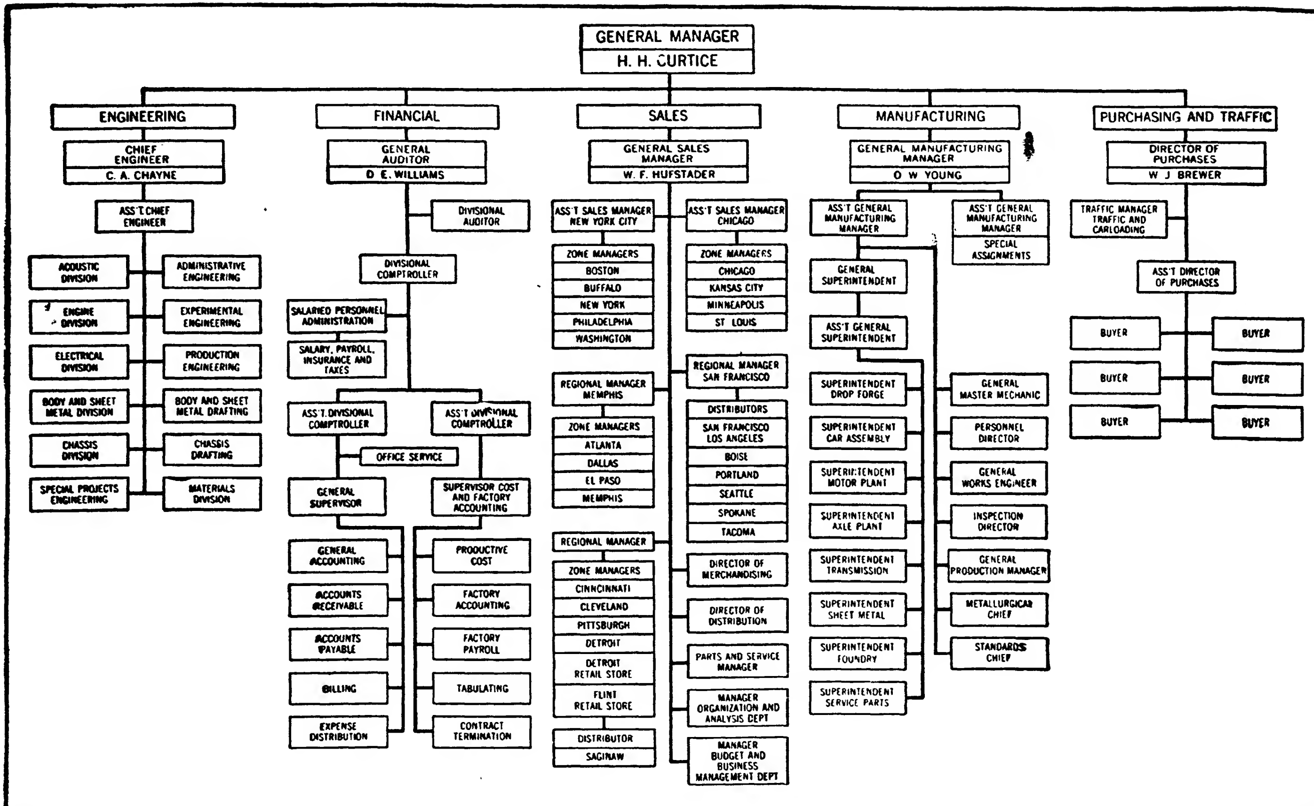


Fig. 6.7. Organization chart of the Buick Motor Division of the General Motors Corporation.

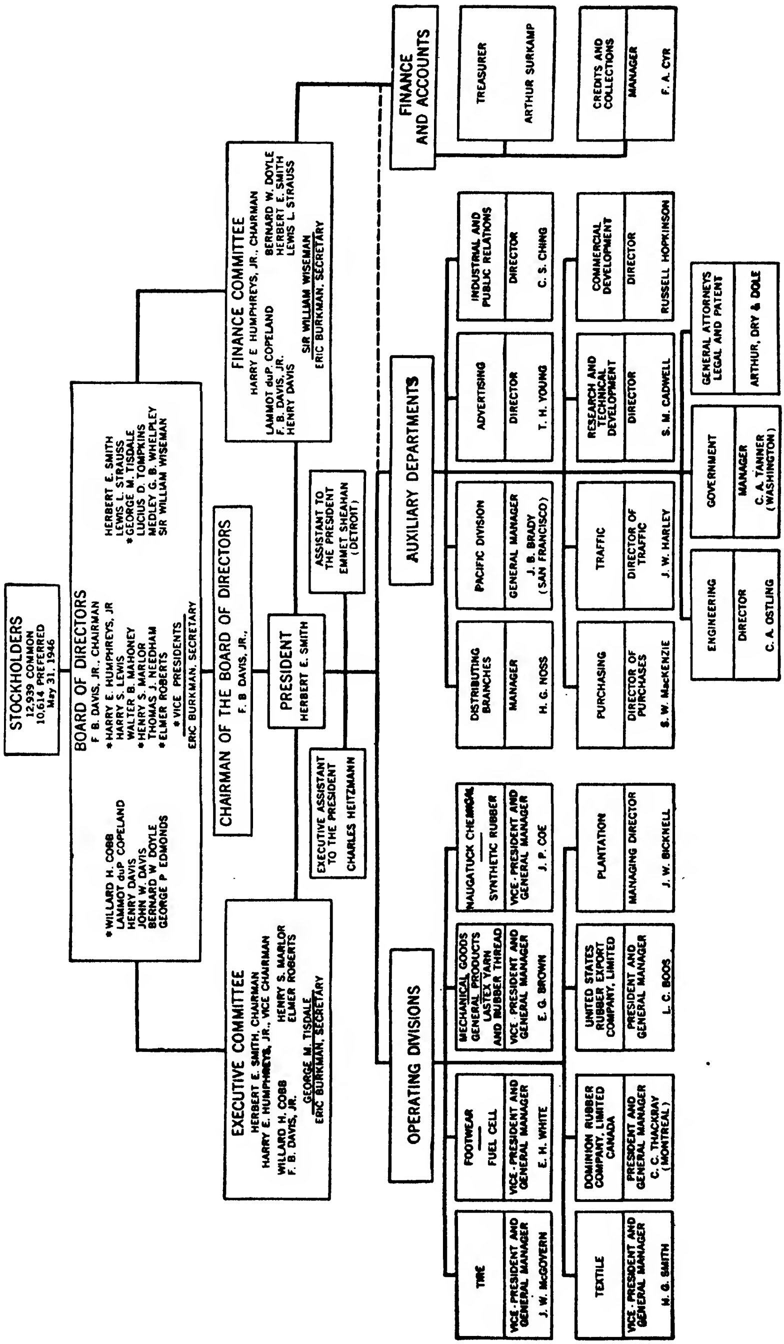


FIG. 6.8. Organization chart of the United States Rubber Company.

and costs for Plant No. 3, and supervises experimental work and designing, particularly for Plant No. 3.

The treasurer supervises financing, advertising, bookkeeping records, and purchasing for Plant No. 2. He is office manager for Plant No. 2 and supervises all accounting work for the entire organization. Plant No. 2 is a foundry in which all castings for the firm are made and also

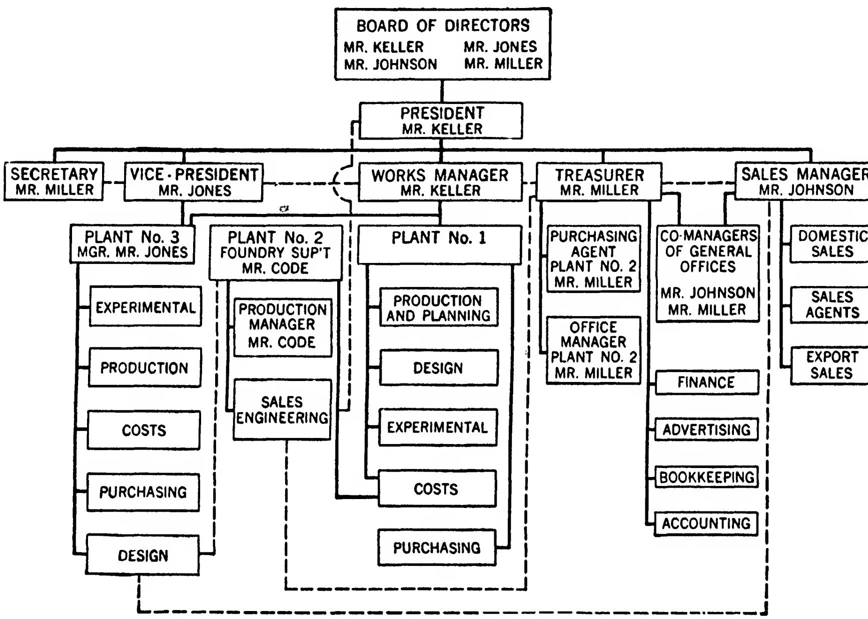


FIG. 6.9. Organization chart of the Oliver Machinery Company.

engages in jobbing work in heavy machinery castings and die casting for outside firms. This plant is operated as if it were a separate organization. The treasurer and the sales manager are comanagers for the general office, which is located in Plant No. 1.

This organization, as has been stated, is built around the capacities of the respective major officers, president, vice-president, secretary, treasurer, and sales manager. It is conceivable that difficulty might be encountered in finding a man to take the place of any one of these officers, with the possible exception of the sales manager, should he suddenly be removed from active service by illness or death. As it is now constituted, this corporation has successfully weathered the storms of the depression and the war years, and it undoubtedly has the capacity to adjust its organization to the abilities of the men available when the present active

officers retire. Organization is not an end in itself but a means of achieving the end.

Companies without organization charts. Because they feel that organization charts restrict the scope of activities of executives to too great an extent, some companies refuse to use them. It should be freely admitted that the organization chart is merely a cross-sectional picture of the organization and may have to be changed often unless it merely gives the functional relationships and not the names of the persons discharging these functions. In most cases, however, it is well worth the thought and effort expended upon it. It necessitates management's thinking through the structural relationships and the fixing of responsibility. It also serves as a valuable aid in introducing new men to the organization. The organization chart loses its value unless it is kept up to date.

CHAPTER 7

ORGANIZATION, COORDINATION, AND MORALE

Coordination. Coordination may be defined as the synchronizing of effort from the standpoint of time and the sequence of execution. It is the common element in all managerial effort regardless of the particular organization structure. The demands made upon management to secure effective coordination vary with the type of organization structure used, the degree of indoctrinization of the personnel in the organization's objectives, procedures, and policies, the caliber of the supervisory personnel, and to some extent upon the age of the operating organization unit, together with its traditions and customs. For instance, an old, well-established institution manned by persons who have been accustomed to working together for years will require less direction from top management to secure the desired coordination than will a new endeavor using the same organization structure but lacking personnel experienced in working as a team. This does not mean that organization structure has no influence upon coordination. An organization that has no well-integrated production-control department may do a fair job of getting out production, but the time cycle for production will invariably be longer and the work in process will be larger.

Many of the staff departments contribute materially to the coordination of effort. For instance, if each department head hires his own men (as was formerly the custom), one department may be laying off men at the same time that another department is hiring others with essentially the same qualifications. The industrial engineering department, through the authority of ideas, facilitates coordination, particularly in terms of methods, procedures, and balance in equipment or personnel.

Morale. Morale is the prevailing attitude or state of mind of a group. It may vary all the way from the positive morale characterizing a group that has identified its interests with the objectives of the institution to the negative morale of the group that seriously questions ability or willingness of the institution to consider the welfare or interests of the members of the group. The morale may be high in regard to some aspects, such as wages, and low in terms of feeling that the leadership is not impartial in matters of promotion.

A morale-building organization tends to utilize fully the skill, initiative, judgment, and training of its members and through such utilization succeeds in building up these and other qualities in everyone, so that the abilities of all constantly expand, and the organization thus is able to succeed and grow. All members of the organization are encouraged constantly to assume greater responsibilities, at the same time having due regard for the rights of others. Thus all executives become accustomed to think of the duties, responsibilities, and difficulties of their coworkers, with the usual result of coordinate action and growth in capacity of the individual.

In morale-destroying organizations restriction of the individual is the keynote. The organizer has endeavored to impress his will on the daily actions and relationships of all members of the enterprise. Into such organizations individuals enter filled with enthusiasm and a desire to make their tasks and themselves grow and, through them, the business. It is not long, however, before they become aware of the restrictions that have been imposed, and before they learn that the energy they are utilizing in the performance of their tasks is not noticed or is not appreciated. Although they endeavor to utilize some initiative in their daily operations, they find that they are hindered by lack of authority. They try to temper their decisions with judgment, but they find that their decisions are not accepted or are restricted by supervising judgments.

In modern industry not only the executives but also the other workers must have an organization sense. "Followership" is as essential as leadership. Organizations cannot be built up through the executives only. Loyalty is one of the finest attributes of any member of an organization, but a management must deserve loyalty before it will receive it.

Morale-destroying organizations are generally overorganized, although underorganization may also be morale-destroying. The very elements which promote morale destruction, if applied in proper quantities, build morale.

Conditions that depress morale. The most important morale destroyers are: too fine division of authority or responsibilities, too many supervisors, improper selection of personnel for new or expanded duties, overreliance on organization charts, and too few real executives. Any of these conditions is likely to arise in the course of building an organization, and their effect must be kept in mind constantly in considering the fundamentals of organization and other factors which are likely to cause them to appear.

Too fine division of authority or responsibilities. Too fine division of authority or responsibilities is likely to result if careful thought has not been given to differentiation between activities. The division of authority

and responsibility must not be carried to a point that will preclude original thinking by subexecutives. This does not mean necessarily that responsibilities may not be divided finely, nor that those entrusted with responsibilities may not receive the expert advice of others in particular phases of the work. It does mean that considerable initiative in the particular line in which he is engaged must be left to each executive, in order that he may take pride in the accomplishment of some definite phase of the work, however small.

Effective leadership is half of an executive's job. It cannot be expected to flourish where individual growth has been prevented. Good executives will not tolerate such restrictions and will seek other connections. Poor executives constantly become poorer, as they rely always on instructions from above. The final result is that confidence in the business is lost by those on whom its success largely depends, the subexecutives in direct charge of operations.

Too many supervisors. Before the introduction of scientific management it was common practice to have line executives overloaded with a variety of duties. This led to the development of the functional supervisor with resultant increased efficiency in many instances. Many of the more able executives, who grasped the advantages of specialization of effort and were willing to adjust their organizations to use the new techniques, early pointed out the fact that there is very definite danger of allowing functions to be created merely because they seem to be different, and without an adequate check being provided to see that they are or can be made to be paying investments. There is a very real risk of developing a situation where "for everyone doing productive work there is another man standing over him to see that he does it."

Balance is needed in determining the number of supervisors required, as well as the number of workers to turn out a given volume of production.

Improperly selected personnel. It is essential that mere seniority within the organization shall not be allowed to govern organization development. The education and the intelligence levels of the persons concerned must be considered. It is true that in large organizations some orderly arrangement of promotion with length of service as a factor must be worked out, or the effect will be the same as constantly bringing in new people for positions near the top of the organization; nevertheless seniority cannot be made the sole or even the most important basis of promotion. If it is seen that length of service clearly outweighs value of service in reassigning duties or filling vacancies, the direct effect will be a let-down of effort by those subexecutives on whom the success of the enterprise most depends—those near the bottom of the ladder. The deadening effect of the application of the seniority rule can be found in the

listlessness displayed by subexecutives and clerks in the offices of certain large railroad companies which base their promotion or organization-development policy solely on seniority. Thus it is clear that the manager, in building organizations, must consider his new or expanded duties in the light of two almost opposite reactions of his personnel: the aversion to the newcomer and the necessity for—but, at the same time, the impossibility of—following the seniority principle. The effective organization is the one in which the tortuous channel around and between these conditions has been traveled with success.

Misuse of organization charts. If the organization chart is looked upon as recording all the lines of supervision and all the responsibilities which have been placed, it will soon be found that its influence is too restricting. It tends to make the limitations on the duties of the various individuals too stringent and promotes the attitude that anything which does not pertain to a particular department or section is no concern of the persons within that unit. Such an attitude prohibits analysis of the work of others and therefore eliminates the necessary coordination which follows a knowledge of the other man's difficulties. Even if responsibilities are stated rather definitely under each main department or section, and attention is called here to the main lines of coordination, the most important coordinating activities of good executives which they take upon themselves in the daily conduct of their tasks cannot be shown adequately.

Frequently, since the greatest ability of particular members cannot be depicted satisfactorily, the chart seems out of balance, so that the whole organization questions it. Leadership frequently is made effective through some person rather far down in the organization scale. Divisions or departments of the business may be built around the personal qualities and problem-solving abilities of this person. If the organization chart is looked upon as more than a guide, this man's ability to lead and coordinate actually may be throttled. The free-lance assistant to the general manager, who can eliminate much friction before it gets started, has duties which it is most difficult to portray satisfactorily on a chart.

These objections and inherent defects of organization charts do not indicate that the charts should be eliminated. Charts frequently may be made more workable if supplemented by standard-practice instructions, but of themselves charts can never be regulations for organization operations.

Too few real executives. A common characteristic of a morale-destroying organization is reliance on too few real executives, that is, having as supervisors in most phases of the business the clerical type of individual, with a few real executives holding the guiding reins. Heads of divisions or sections should be real executives. They should be able not only to

control and supervise but also to inspire the men and women under them to better and greater activity. Men of real executive caliber are needed for effective operation. Organizations, like other structures, must be built to survive the maximum strain which may be placed upon them. In the ability and action of the executives throughout the organization lies the factor of safety. If provision has not been made for this factor of safety, the structure may collapse under the strain of unusual pressure.

Morale-building organizations. An organization that builds morale is one that follows carefully the *primary fundamentals* of organization and has carefully developed the *operating fundamentals* of organization to implement them. To acquaint the personnel of an enterprise with its aims and objectives is a function of leadership. It is largely achieved through training. Development of responsibility within the definite lines of supervision requires first the laying down of such policies of supervision (a top planning assignment) and then proper delegation of responsibility (a leadership assignment).

Regard for the personal equation is primarily an attitude arising from the individual's social background. It is an outgrowth of his respect for the dignity of the individual. The mere fact that a person desires recognition himself does not imply that he will grant it to others below him. Attitudes toward the recognition of the personal equation are formulated over a long period of time. Similarly, a long time is required to change them. Group conferences in which the chief executive sets forth the company's policies regarding men are helpful, but the day-to-day examples of the superior executives are more influential than theoretical discussions.

A technically qualified work force, including supervisors as well as manual workers, constitutes a group that possesses confidence in its ability to achieve the institution's goals. A group of this type can be assembled only through careful selection and purposeful training.

Proper organization structure will not assure the desired results, but it will produce an atmosphere in which these results are most likely to be attained. Many executives who are not organization-minded underestimate the effect of proper organization structure. They assume that the capable man will rise to the top in any event. Such is far from the case. A capable man who respects the rights of others may readily be passed by an unscrupulous climber with less ability than the man who will not stoop to intrigue.

Personal integrity on the part of the executive force, coupled with dynamic, inspirational leadership and a properly balanced organization structure, constitutes an ideal seldom completely realized but one worth constant effort to attain. Under such circumstances morale is certain to be high, discipline will be positive rather than negative, and the institution

will move slowly but resolutely toward its goal. The student should remember that morale is a desired characteristic of all organizations, the church, government, army, department store, and fraternity, as well as an industry.

Some executives are greatly surprised when they take over bodily a form of organization that has worked successfully in a similar enterprise and fail to get the same results. Such executives usually mistake the form for the substance and are unaware of the fact that successful organizations are usually the result of slow, painstaking adjustments and growth, that custom and tradition are powerful factors not to be ignored in dealing with human relationships, and that an organization structure has to be adjusted to the capacities of the available personnel. A particular organization setup may well be a success if installed gradually, permitting persons to make needed adjustments without undue emotional strains, whereas the same organization will result in dismal failure if inaugurated too rapidly, particularly if forced from the top. Time for seasoning is as necessary in securing a smooth organization structure as in many other relationships.

Clearly defined responsibilities. One of the primary fundamentals of organization is clearly defined responsibilities. A recognition of responsibility, with full knowledge on the part of the recipient that he has concurrent authority, is a strong motivating force. It results in a high type of morale when authority and responsibility are properly balanced and generally recognized throughout the organization. The proper division of authority and responsibility must avoid too fine a breakdown as previously described under morale-destroying influences. This principle of fixed responsibility should extend down to the individual worker. The typical workman likes to feel that he has a responsibility in keeping with the work he does.

When an individual worker, subexecutive, or executive undertakes to discharge the clearly defined responsibilities that are his, he usually develops a keen organization sense for the rights and duties of others. This recognition of interdependence within the organization fosters a spirit of cooperation, which characterizes a group possessing a high degree of morale. A lack of definite responsibility and authority to meet this responsibility results in hesitancy and uncertainty, whereas a full knowledge of fixed responsibility and authority produces mutual confidence between members of an organization and a positive attitude toward the objectives of the enterprise.

Although it is highly desirable to have organization procedures a matter of record so long as they do not become inflexible, this becomes less necessary where responsibilities are definitely known. If the organization

has attained sufficient age to have undergone a thorough indoctrination with well-developed company policies, many of the procedures are automatically carried out as a matter of tradition or custom. Fixed responsibilities within an organization tend to develop men who are capable of assuming the burdens of these responsibilities and willing to do so. The fact that men are accustomed to stand on their own feet, operating of course within certain well-established practices, develops a group of minor executives who are capable of meeting unusual situations and emergencies. In such an organization the full utilization of the sound principle *that decisions should be made at the lowest level within the organization where the facts are available and competence exists to decide* is encouraged. Fixed responsibilities within an organization promote maximum use of this frequently neglected principle.

Adequate supervisory force. A well-supervised organization possesses one of the necessary prerequisites to achieving the major objectives. There is no tonic quite so stimulating to morale as attaining a well-known objective or task. Too many supervisors get in each other's way and destroy morale. On the other hand, too few supervisors create unnecessary delays which likewise destroy morale. The ideal situation is a matter of delicate balance between too few and too many supervisors. The type of organization determines to a considerable extent the exact number of supervisors required. The nature of the enterprise is also a determining factor. An organization manufacturing a standard product on a mass-production basis will require a relatively smaller number of supervisors than one manufacturing a variety of unstandardized products. An overworked supervisory force is tempted to devote its attention to apparently more pressing needs, frequently overlooking the little details that mean so much to good morale.

Unadjusted grievances tend to be magnified in a geometric ratio to the time elapsing. Although this rule does not hold with mathematical exactness, it is nevertheless generally true. Undoubtedly the most effective way to insure prompt adjustment of grievances, with resultant morale-building effects, is to have adequate supervisors well trained in the principles and practices of the company.

Effective functionalization within an organization encourages morale building. This principle can be carried out only where adequate supervisory personnel is available. Skilled men in a given function bring to their work an assurance that provides the positive attitude so necessary to good morale within a group. Even in organizations having a strong central planning department, there still remain much analysis and planning for the individual supervisors. In general, these functions will be carried out thoroughly and competently only when daily tasks are not so

pressing that they leave no time for anything else. It takes time to plan for the organization as a whole, and it also takes time for the individual to plan and analyze his work. This is just as true of functional supervisors as of general supervisors.

Proper selection and promotion of personnel. One of the positive contributions of functionalization in management has been the development of the personnel department. This department is charged primarily with the responsibility of properly selecting personnel and to a lesser degree with promotions within the organization. Men who are well equipped by natural abilities and acquired skills to do a given task will usually find satisfaction in its performance. A group of men who get personal satisfaction out of their work will usually be a happy group. Another factor that goes a long distance in adjusting men to their work is proper introduction to the job.

A carefully organized promotion policy does much to encourage organization pride and morale. Most enterprises claim to have a definite program for promoting qualified men from within the organization. Few of them, however, have a specific program and adequate records to make such a program a reality. A thorough-going program requires long-range planning of a high type. It pays well in the long run, but it also involves costs in the short run. It is seldom that a man is found within an organization who fits the exact requirements of a position offering promotional possibilities, particularly if this position is a newly created one, unless a definite program has been in operation to prepare men for promotion. The easy method is to go outside to find a man for the opening. Such a procedure tends to discourage the men within the organization who are ambitious to advance. This does not mean, of course, that men should never be brought in from the outside, because there is the danger of inbreeding. Moreover, a new viewpoint is frequently stimulating. An occasional new man will also serve as notice to men within the organization that they must qualify if they expect to be promoted.

A well-known Chicago manufacturing company with branches throughout the world became keenly conscious of the depressing effect of its slow promotional opportunities in the summer of 1938. It was faced with further curtailment of activities, which meant stepping back some of its minor executive groups if previous practice was followed. This company has a long and successful record of enlightened personnel activities. Many of its major executives had reached the age where they were eligible for retirement, although several of them were still active and not particularly anxious to retire. Pressure was exerted to cause several of them to give way to younger men, thus making possible a series of chain promotions

which relieved considerably the pressure all the way along the line with a very salutary effect on morale.

At times it becomes advisable in an enterprise that has a relatively slow growth to promote men out of the organization. This does not mean that the business discharges men, but rather that the management learns of openings for them in other organizations. Worthy men who have no prospects of promotion within the organization in a reasonable length of time are told of these outside opportunities and aided in making necessary contacts. Such a movement on the part of management soon becomes generally known within the group, and the feeling that merit is rewarded promotes company morale.

Dynamic leadership. Men like to be led by a strong leader. Sound policies and organizational procedures inaugurated by a feeble, colorless leader may be recognized, but they are immeasurably less effective than when vitalized by the intangible factor of a strong personality. This item is particularly important to subexecutives who come in direct contact with the working force as a whole. The purely intellectual leader may succeed at the top if he selects wisely the lieutenants who do his contact work for him. The dynamic leader has confidence in himself and the capacity to inspire confidence in others. He knows what he wants and goes after it. He has a definite program for himself and his organization. He knows his own job and expects his subordinates to know theirs. He willingly delegates responsibility and authority and is exacting in demanding performance. He possesses vision and a constructive imagination. Such a leader is loyal to his associates and commands loyalty in return. All these characteristics are seldom found in one man. It is rare indeed that many such men are found in a given organization. Unfortunately many leaders possessing dynamic characteristics temperamentally dislike details. The organization specialist is constantly faced with the problem of compromise in selecting his personnel. Special selection and training are valuable aids in building an organization manned by strong personalities that are accustomed to giving adequate attention to necessary details. The principle of balance is needed in developing dynamic leaders, as well as in all other management relationships.

Authority. The proper allocation and use of authority have much to do with the morale of a group. The allocation of authority is primarily a responsibility of top management, functioning through the organization structure. The use of authority is somewhat influenced by the chain of command but primarily by the personal attitude of the individual exercising the authority. For instance, in a five-man chain of command from the chairman of the board of directors to the work level the ideals of the organization may definitely fix authority and responsibility and have as

a slogan concerning authority, "Use it sparingly; display it never." Nevertheless in this organization the third man from the top may give only lip service to the ideals and in fact may display his authority all too often. He is likely to be a man who has considerable capacity but who suffers from a feeling of insecurity.

In order to see that authority is properly used, top management must have other checks. The personnel department, the industrial engineering department, the inspection department, and the accounting department provide some of these checks.

Authority is a right that inheres in an individual, department, or organization to decide and to "command" when commanding becomes necessary to discharge the responsibility accompanying authority. It should be recalled that to command does not imply to order without regard to the rights and dignity of the recipient of the order. A request made by a person in a position of authority and responsibility is the customary method of giving orders. In military drill and during an emergency, of course, a direct command may be used. The time and circumstance greatly influence the exact method employed in a particular instance.

Consultive supervision. Consultive supervision is the most effective method of exercising authority in business. It may also be used advantageously in other types of organization. Consultive supervision implies that those supervised are asked to give their opinions regarding the best method of getting a particular task done. Such a procedure brings collective concentration and effort to bear upon a given solution rather than the ability and thought of one person. It definitely raises morale and is an excellent technique for getting things done. The foreman who practices consultive supervision will find that detailed follow-up is not so necessary as when orders alone are used.

What supervisors think of morale factors. A few years ago the author was privileged to conduct a series of conferences with plant executives of a large automobile company in connection with their executive-training program. Approximately three hundred men ranging in executive rank from plant managers down to assistant foremen participated in these conferences. Each conference consisted of a group not exceeding twenty men. The tabulations given below illustrate the reactions of practical men to the influence of plant morale.

I. Plant morale is the state of mind of a group based on:
   1. Loyalty.
   2. Cooperation.
   3. The "will to do."
      a. Interest.
      b. Energy.
      c. Initiative.

II. The following items must be avoided if a high type of morale is to be maintained:

1. Favoritism toward individuals (nepotism is particularly bad).
2. Preference to certain groups because of religious, fraternal, or other affiliations.
3. Display of anger by supervisors.
4. Hasty and unwise decisions.
5. Wage discriminations.
6. Lack of punctuality.
7. Untidiness in the shop.
8. Agitation and the spreading of rumors.
9. Misfits or unfits, who are frequently problem employees.
10. Carelessness.
11. Unfulfilled promises.
12. Jealousy.
13. Dishonesty.
14. Manifestation of prejudice.
15 Hasty or unfair discharges.
16. Belittling of management's policies by a subexecutive.
17. Paternalism.
18. Too many bosses.
19. Too much display of authority.
20. Poorly maintained equipment.

III. The following items must be considered in maintaining a high type of morale:

1. Square dealing with men.
2. Setting a good example. (Do not ask others to do things you would not want to do yourself.)
3. Recognizing ability in others and giving credit where credit is due.
4. Encouraging the discouraged. (Show a personal interest in your men and their problems.)
5. Planning the work of the department. (If possible, maintain a steady flow of work.)
6. Keeping tools and equipment in good working condition.
7. Encouraging suggestions from others.
8. Maintaining safe working conditions.
9. Giving attention to good housekeeping practices.
10. Having a well-understood and definite program for promotion.
11. Encouraging loyalty by being loyal to others.
12. Encouraging cooperation by creating conditions that are conducive to it.
13. Maintaining an equitable wage program.
14. Maintaining discipline.
15. Issuing clear and adequate instructions.
16. Keeping all promises. (If conditions should change so that a promise cannot be kept, explain the situation at once.)
17. Avoiding overlapping of responsibilities.
18 Providing strong leadership. (Men like to follow a man who knows where he is going.)

A perusal of these positive and negative factors may show some duplication in minor details. These executives were not particularly trained in

the art of expression for publication. They clearly recognized the importance of morale in successful management and spoke out of their many years of experience concerning items that they had observed to destroy morale. They were equally convinced, even though somewhat idealistic, regarding factors that produce a cooperative organization with a "will to do."

CHAPTER 8

PRODUCT DEVELOPMENT AND RESEARCH

The need for research. Any business of substantial size operating in a competitive market is faced with two types of situations demanding technical research: (1) the need to solve problems arising in connection with current operations, and (2) the need to devise new products, to improve the present product, or to find new uses for the present product or a new one. Regardless of how smoothly an industry may be operating at a given time, new problems arise that require research to overcome. In a competitive economy new products or improvements in an old product become a necessity to keep abreast of the parade. Some small enterprises in their early stages may not be in a financial position to engage in elaborate research activities. As they become well established, however, they can no longer afford to follow the leadership of others but must be in a position to hold their own in the competitive race. Most companies grow slowly and enter research as a part of that growth. This statement, of course, would not be true of a new undertaking sponsored by a large organization, such as the General Motors Corporation or the E. I. du Pont de Nemours & Co., Inc., which has at times conducted exhaustive researches in its main laboratories and then built complete plants with the last word in technical equipment to exploit the findings of its researches.

Historical background of product design and research. Since the turn of the century such rapid progress has been made in product development and research that we are likely to underestimate the contributions of the past. A critical evaluation with full appreciation of past achievements, in the light of the limited techniques and equipment previously available, should inspire rather than discourage the present investigator.

Before the discovery of America the natives of Guatemala were using fast vegetable dyes. The early Egyptians processed copper in a manner which has been claimed to defy duplication even today. Early histories of China report the use of gunpowder. Five thousand years ago the Mongolians were using tea leaves to treat burn trauma; in 1925 the Henry Ford Hospital of Detroit announced the modern counterpart of this remedy—the tannic acid treatment for burns. Modern scientists are striving to unlock the past. The Rockefeller Institute has sent an expedition into

the jungles of Brazil to study the herb treatments used there, hoping to discover in them valuable principles which are unknown to the rest of the world today.

Many of the materials of nature are not so satisfactory as man would have them be; they are heavy when he would prefer them light, soft when he wants them hard, and solid when they should be liquid. The more exact scientific methods of the nineteenth century freed man from many of these handicaps. Schoenbein nitrated cotton and obtained nitrocellulose, which Hyatt discovered how to plasticize into a pliable product. Du-Chardonnet completed this nitrocellulose cycle by spinning the first filament.[1] Despite the fact that we think of rayon as a modern product, its early beginnings appeared in the middle of the last century. Today American chemical research in rubber and synthetic fabrics ranks second to none in the world, as does our medical research. World War II produced synthetic rubber on a commercial scale and unlocked the secret of atomic energy. We have long led the field in mechanical research and development. Future developments in chemistry and atomic energy challenge one's imagination.

Conflicting interests in product design. The sales division tends to work towards diversity, whereas the production group strives for standardization. The factors encouraging diversity include:

1. The necessity of meeting the needs, desires, and purchasing capacities of various consumers.
2. The gain in sales appeal through product changes, so that the merchandise appears to be up to date.
3. The need to meet price competition by changing construction of the product in minor details so that the price may be slightly reduced.
4. The necessity of meeting several competitors' products of varying design or varying materials.
5. The limitations imposed by process or design patents of the particular company or its competitors.
6. The desirability of developing several competing but dissimilar lines to enlarge the number of retail outlets.
7. The continued development of technical processes and equipment and adjustments to take advantage of the possibilities of these developments.

The design engineer who can devise means of creating diverse-appearing products from standard materials and processes is usually the leader in his field. The managerial factors which exert an influence toward standardization include:

[1] Much of the material in this paragraph is adapted from a speech delivered by Paul F. Ziegler, research director of Bauer and Black, Chicago, Illinois, before the Chicago chapter of the Society for the Advancement of Management.

1. Lower investment in plant, equipment, materials, and finished inventory.
2. Resultant price reductions, so that the market for the product is enlarged.
3. Interchangeability of parts if product is mechanical.
4. Possibility of development of automatic equipment or standardized chemical or mechanical controls.

Economic considerations. Before deciding to undertake a research project or to exploit the results of research already accomplished, it is necessary to analyze the economic implications. Investment in machinery and equipment must be gauged by the immediate savings which will be made, by the necessity of reducing production costs to meet competition, by the likelihood of new processes being developed to replace the equipment whose purchase is being contemplated, by the life of the equipment, by the condition and manufacturing possibilities of the equipment already owned or competitive equipment which may be purchased, and by the prospective length of life of the design of product on which the contemplated new equipment will be used.

Research and analysis inform the factory owner that he can improve his product or cheapen its price by improving his production facilities, but in times of depression he knows that he must maintain his balance sheet in the most liquid condition possible, that he must scrape along with the old-style machine or the old-style process a little longer, no matter how dissatisfied with it he may be. Large aggregations of capital secure their greatest relative advantages in periods of depression. Enterprises in a strong financial position do not lay off their research workers and do not stop process development; they keep at work, bide their time, and, when conditions improve, produce commodities that are demanded by the consumer. Their competitors then attempt to follow, and those who are unable to do so because of financial or patent reasons are soon out of the race.

Different kinds of research. Research may be defined as the search after new information by the experimental method. Pure research seeks truth for its own sake without regard to its utility, whereas applied research seeks to solve specific problems with consumer utility as a direct incentive. Some authors have used the terms "extensive" or "fundamental" research to refer to pure research and "intensive" research to denote the effort to solve specific industrial problems. Intensive research strives to enlarge our knowledge about existing things or things that might well be, so as to enable us to improve them or reduce their cost, or both, as well as to create a new utility or service. Extensive research seeks to extend the frontiers of knowledge for its own sake. Both types of research have a place in our social structure, and neither can truthfully claim any su-

perior status over the other. Industry and commerce are primarily interested in research in the economic and social sciences and in materials, equipment, and processes. Industrial management concerns itself largely with research in materials, equipment, processes, and the product manufactured. An industry which neglects research will survive foreign competition for a time only by cowering behind tariff walls. Industry is primarily engaged in intensive research; extensive fundamental research, however, serves as a stimulus to more effective intensive research.

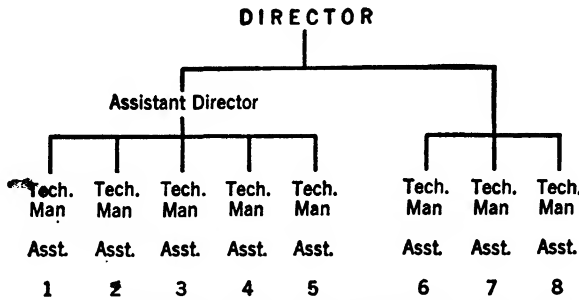
Organization for product design and research. Many phases of design and research require painstaking preparation and exhaustive investigation. Active participation in production routine is not conducive to this type of work. It will often be neglected entirely unless a particular executive has a special personal liking for it, and in this case production not infrequently suffers from lack of attention. It is doubtful if there is any phase of organization where specialization gives greater returns than in the field of design and research. Creative work of any type requires time.

The mistake is often made of laying the major emphasis on buildings and equipment, but in reality the buildings and equipment may be meager for most research, provided that the state of mind is right and time is available to pursue the inquiries. The essential factors that foster research and product development are time to pursue the investigations, an inquiring state of mind supported by sufficient effective training or experience in systematic investigation, and the facilities necessary to carry on the research.

The product engineer should occupy a position of trust and responsibility in the organization. In many of the larger enterprises he is a vice-president on an equal status with the sales manager and the factory manager. The research division may be a section of product engineering; product engineering may be a division of research; or the two may be entirely separated. Where the two are joined in the same organization, there is more likelihood of a closer tie-in with actual production problems. If research is really to function, it must be allowed to work on its primary objective and not have its efforts expended on tasks that belong to the producing departments or inspection. It is always a temptation, particularly in highly technical processes, to call upon the research or development department when production encounters difficulty. Regardless of the position in the organizational structure of the product engineer, if he is to be effective he must work closely with the production, purchasing, and sales departments.

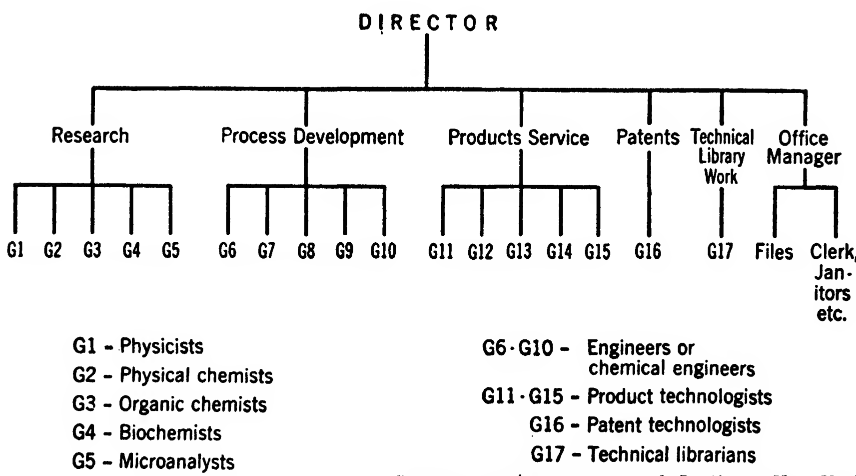
Figures 8.1 and 8.2 illustrate the organizational structure of research departments, depending upon the number of men in each. In Fig. 8 1 the

department is composed of ten technical men. Groups 6, 7, and 8 are primarily concerned with products service and report to the director, since he is presumed to have a primary interest in the quality of the products. Groups 1 to 5, working under the assistant director, will



Courtesy, Industrial Research Institute, New York

FIG. 8.1. Organization of a research department having ten technical men.



Courtesy, Industrial Research Institute, New York

FIG. 8.2. Organization of a research department having one hundred technical men.

handle both process development and pure research, with primary emphasis on process development. Patents in such an organization are usually handled by the director in consultation with outside attorneys. Figure 8.2 illustrates an organization having one hundred technical men, hence the higher degree of specialization. In a research organization there is frequently a nontechnical helper or other clerical aid for each technical person.

Fundamental considerations in product design and development. The persons charged with the responsibility of product design must bear constantly in mind certain basic fundamentals, or their efforts may not be most efficiently directed. A few of these considerations may be stated as follows:

1. The desire of the consumer for utility, quality, style, and color within a given price range must never be ignored.
2. The cost of product development must be kept within the capacity of the business enterprise to pay.
3. Due regard must be given to the effect of introducing the new product upon the rest of the company's products, both from a selling and a manufacturing point of view.
4. There is need for coordinating the various departments interested in design, such as the methods department, the manufacturing division, the purchasing department, the sales department, and last but not least the finance division.

The consumer desires. *The major objective of a business enterprise is the satisfaction of consumer wants in order to realize a profit on operations.* Since production is largely in anticipation of demand, it is necessary to anticipate the consumers' desires in marketing a new product or an improved one. The consumer wants not only style and color but also utility. A vital factor from the standpoint of consumer utility is ease of maintenance. The product engineer should strive for accessibility for maintenance and keep in mind that the product will be repaired in the field where facilities are not the same as in the producing plant. Low maintenance cost provides a strong selling point.

Some enterprises have sought to find out from the consumers themselves what they want in a product. Mr. Weaver of the General Motors Corporation has developed an interesting technique for this purpose. He sends out thousands of attractive booklets that show current and possible designs, colors, upholstering materials, improvements, and other features. These are conveniently arranged so that the recipient may easily check his preference and insert the booklet in a return envelope. From these replies the corporation can measure with a high degree of accuracy what the consumer wants. There are special market-research corporations that will undertake a consumer study for a fee. They may use a questionnaire or send out representatives to interview a representative sample of customers.

Costs of research and development. The development engineer seldom can estimate accurately the cost of a given program at the time of his initial request for funds. If it is a simple program and he knows exactly what has to be done, his cost estimate will be fairly close. Such cases are rare in real development of a new product or process. Usually there

are so many unknowns that about all that can be done is to give an enlightened estimate of expenditures to be made within a given time. Just how far the project will be advanced within this period of time it is difficult to predict. The sound procedure is to budget developmental and research costs and to keep an accurate record of all expenditures for each project. Such a program will tend to keep costs in a balanced relationship to each other and prevent all available funds from being spent for one purpose when other problems also demand attention.

The question of what percentage of profits or of sales should be spent in research is frequently raised. The answer is sometimes estimated to be ten per cent of profits or two per cent of sales. Naturally such estimates are in no sense final. When a particular company is faced with a number of problems needing solution, the budget for research may readily be in excess of the estimated two per cent of sales, provided of course that the financial situation is such that funds are available. Research is both an insurance against unexpected developments and a speculation in possibilities of future business. It is difficult to predict where the insurance aspects cease and speculation begins.[2]

Coordination of various interests. If a new product will compete directly with a product now in the line, management will have to decide in advance just what policy to pursue. Should the product be marketed by the same sales group or have a different sales organization, such as is used by General Motors in marketing the Oldsmobile and Buick automobiles? Will the present manufacturing facilities be adequate for the old products as well as the new? If the new product is the same in type but different in quality from the regular line, what effect will producing the new one have upon the production of the old line? Will the new product tend to lower or to raise the quality of workmanship on the old one if both are to be produced by the same workmen? These and other similar questions must be answered by management in advance of production if unfortunate results are to be avoided.

The logical method of resolving the various conflicts of interest is to have all interested divisions a party to the final decision. As a matter of fact, the design engineer may well consult the methods department and the manufacturing division as he progresses. Such coordination may easily result in modifications of design that do not interfere with the basic operation of the product yet make possible the use of present equipment, thus avoiding unnecessary expenditures for new equipment or later changes in design. By working closely with the sales department, the

[2] See Industrial Research Institute, *Organization of Technical Research in Industry A Monograph,* New York, 1945, p. 5.

design engineer will have the benefit of practical customer reaction as well as the enthusiastic support of the sales group in marketing a product for the design of which they feel some responsibility. The purchasing department may render valuable suggestions regarding economies in buying certain materials or parts that may be specified especially in terms of standards and dimensions that are used in the trade.

Procedure in research and product design. The original request or initiative for a given product design or a research project may come from a customer, the sales department, an officer of the company, or the major executives as a group, or as the logical result of evolutionary product development originating in the problems facing the business. The required development or research may arise from the company's purchase of an invention or partially completed research. More commonly the work arises out of internal progress. The management of an automobile industry, for instance, may decide that it desires to produce a car that will sell in the $900 class. This, then, will become the first controlling factor. There being a fair relationship between selling price and weight of a car, the approximate over-all weight may be settled in advance. The next decision may well be wheel base, concerning which the sales department may agree merely to meet current competition; in this event the over-all dimensions are already established by the trade. Since there are many specialized parts in an automobile, the chief product engineer would then assign to each special group its particular task and give each group approximate requirements concerning weight for each unit and cost limits. Some of these special units are the frame, lubrication of chassis, the engine proper with a subdivision of ignition, clutch, and transmission, spring suspension, wheels and tires, and body. Each of these major heads may have several subdivisions; the body, for example, will have at least body contour, paint, trim or upholstering, and body hardware. Since practically all cars give satisfactory performance, the actual mechanical working parts are fairly well standardized, and established practice may be followed with minor improvements that may reduce costs or increase efficiency. The general appearance of the car will greatly influence its popularity with the buying public; hence the design of the body proper, cowling, and radiator must receive special attention for style appeal. A specialist may work on the rear, another on the side view, another on the windshield, another on the hood and cowling, and still another on the radiator. The composite efforts of these specialists may then be put together into one drawing to give the general picture of the projected product, which may have to be modified if the various parts do not harmonize. Another approach is to have an artist sketch the completed design, make changes until it meets the approval of the

major executives, and then assign to each specialist his segment of work to harmonize with the artist's approved design.[8] A temporary wooden or plastic model will then be made, painted, and possibly upholstered to serve as a complete model. This may be changed until it receives final

Courtesy, Fisher Body Corporation, a Division of the General Motors Corporation

FIG. 8.3. A full-sized blackboard drawing, and an engineer determining the body construction for a new model.

approval; the dimensions of the approved model are then transferred to an aluminum sheet to avoid distortion arising from temperature changes in the room. From this metal sheet, body dies will be built and actual production will later be run. Figure 8.3 shows body engineers at work. Any major mechanical changes that have not been previously tested on the road will receive exhaustive road tests before the new car is marketed.

[8] Working from an artist's conception has become increasingly popular in recent years.

On receiving a request for research or upon conceiving a project, the first step might be called a "library exploration" to find out what has already been accomplished in the field. This exploration, which includes a search of the company's own files and any published data in the field, is followed by outlining the procedure in the light of the information discovered. In a large or small development or research project at least two types of procedures may be used. One is to assign the entire project to one man to follow through. He is free to call upon other specialists for help and advice wherever needed. The other is for the director or a committee to retain active control over the project and to assign segments of it to specialists, each specialist working on his phase of the work, sometimes without a full appreciation of the major objective of the entire effort. In either case there may be departmental meetings from time to time to discuss the respective projects and thus acquaint the various persons with the work of the others and to get the collective thinking of the group focused upon a given project.

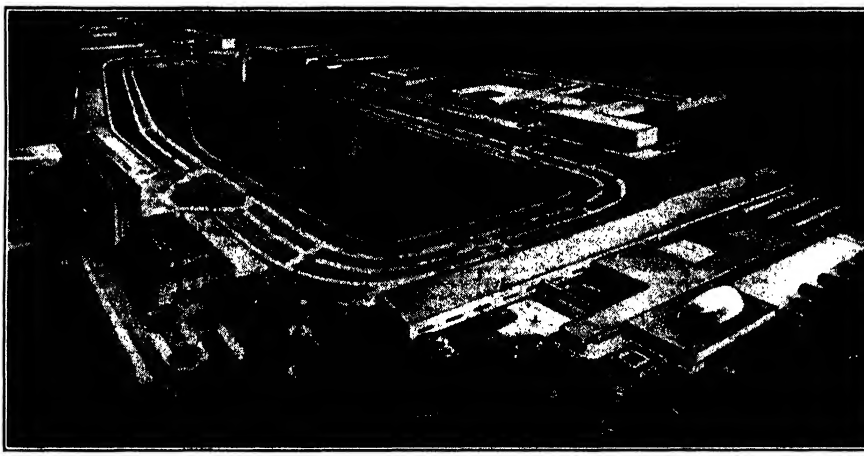
Some rare geniuses may violate all organizational principles and yet achieve outstanding results. This will probably always be the situation; however, modern industrial research has become a cooperative effort involving many workmen and a variety of technical specialists. With the increase in the number of persons actively engaged in research in many industrial enterprises has come the necessity for established procedures and the delegation of responsibilities. The director of a large research department like the proposed General Motors Research Laboratories (Fig. 8.4) must combine an inquiring mind and technical training with high executive ability. Such a large central research unit conducts three different types of activities for the corporation as a whole and the respective operating divisions: (1) pure or applied research initiated by the research unit; (2) "library research" for the respective divisions, since the central research units have a comprehensive library and records of most of the research of the other divisions; and (3) special research activities that any of the operating units thinks can be more effectively pursued by the central staff than by the division research staff. The director of a research staff must be able to recognize questions needing answers and problems awaiting solution and have the capacity to select the most urgent ones at a given time and to delegate each problem or parts thereof to the person best equipped to handle it.

Contributions of the product-design and research departments to other departments.[4] The product-design and research departments may reasonably be expected to render certain special services to the other departments in the organization from time to time, especially to the sales

[4] Adapted from the speech by Paul F. Ziegler, *op. cit.*, pp. 6–9.

department, manufacturing department, and the top management or administrative officers.

1. Sales department. The product-design and research divisions' first responsibility to the sales department concerns the existing products. They must keep the products which the sales department is selling at the top of the list of competing products within the given price range. In the automobile-tire industry the research laboratories are constantly making complete detailed chemical and structural analyses of competi-



Courtesy, General Motors Corporation

FIG. 8.4. Proposed General Motors research laboratories, Detroit.

tors' products. The research and design divisions must not be caught napping by competition.

A sales department has a right to expect from its product-research and design divisions a reasonably constant flow of new products within the field of their operation. A reservoir of possibilities should be available for addition to the line as they may be needed. These possibilities should be well beyond the laboratory stage and should have had some initial field tests, which may be conducted under the direction of the research and design departments. Conversely, it is the responsibility of these same departments to filter out from sales consideration allegedly new and useful products which have no scientific merit.

A third responsibility arises in connection with the interpretation of technical data and results so that they may be used to the best advantage by the sales department. Such technical helps increase materially the effectiveness of sales effort. The advertising function can be more intelligently carried out by a close tie-in with a sympathetic scientific group.

This relationship implies a reciprocal responsibility, mutual respect, and intelligent cooperation.

2. The manufacturing department. Not infrequently in highly technical operations troubles arise which defy interpretation and thereby defy correction—troubles related to chemistry, physics, and engineering, which can be interpreted only in the light of a knowledge of these subjects. In connection with these problems the research staff may render a valuable service.

Another service that the research group may render to the producing group is control over certain highly technical processes. Most of the production control in a manufacturing unit does not require the technique of a research department. On the other hand, certain operations in many industries require close supervision by somebody with research training in order to maintain the desired quality. This is especially true of the manufacture of pharmaceutical products and to a lesser degree of certain phases of rubber manufacture and of the steel industry. The regular inspection department deals with quality maintenance in general, and the research department has no part in this function.

A third contribution of the research department to the manufacturing division is intensive investigation for the improvement of processes. This function in no way replaces the work of the mechanical department charged with methods improvements but rather supplements their efforts, particularly in those phases of the process involving chemistry and physics.

3. Management. In all probability the most outstanding contribution of research to management is the detection of incipient changes that become indicated by the discovery of new facts and new intermediates, either within or without the given enterprise or industry, because it is within the realm of possibility today for a business to be ruined overnight by such scientific discoveries. The multitude of scientific discoveries that are emanating from the many university, industrial, and public laboratories challenge research ingenuity to evaluate them in terms of the organization's products. The newer scientific equipment also falls within this field, as is evident in the adaptation of the principles of radio to the determination of noises in automobile transmissions and the use of X-rays in detecting defective castings.

Whenever scientific meetings are held, reports indicate latent possibilities of new industrial products or processes. It usually requires the applied research worker to detect new-product possibilities in these embryonic stages. Management may reasonably expect this type of service from its research department.

A third responsibility of the product-design and research departments to management lies in the field of patents. Although the actual patent litigation is handled by the legal staff, much of the original data used by the legal division must be provided by someone else. Research and product design result in patents. The laying of a firm foundation for a patent policy goes all the way back to the laboratory notebooks and the records of the product-design department, where intelligent and adequate notations should be made and samples and models developed and carefully filed away. The writing of patent specifications is a cooperative task between the research or product-design representative and the patent attorney. In subsequent litigation the success of the firm often depends upon adequate records which were properly kept and dated during the period of development and research.

CHAPTER 9

SIMPLIFICATION AND STANDARDIZATION OF PRODUCT AND MATERIALS

Standardization of Product

From a production standpoint every organization should prefer to manufacture only one of each type of product in its line. Such a program, although utopian from the standpoint of the factory manager, is impossible in all but a favored few plants. The demands of the trade and of individual customers make imperative the diversification of product that is necessary to meet various needs, desires, and purchasing capacities. Through many years of practice in meeting the desires and needs of the customer many organizations seem to have forgotten that there is manufacturing preference for fewer products. They have proceeded so unnecessarily far in diversifying their lines that it has taken a distinct movement toward simplification, carefully fostered, to bring into prominence the economic and profit-making reasons for the elimination of excessive diversity of product.

The use of standards in management. *A standard is a carefully established norm, measure, or specification covering a method, material, product, procedure, or any other phase of a business process.* The standard is merely the best method, condition, or specification that can be devised at the time, taking into account all the limiting factors, such as price range, available equipment, and material used. Improvements in standards are usually desired and adopted whenever they are found. Although nothing in the idea of standardization precludes change, standardization tends to stabilize, thus preventing modifications other than improvements.

Standardization and simplification defined. In general production discussions the terms "simplification" and "standardization" are frequently used interchangeably. Some writers on the subject distinguish between simplification and standardization.[1] When the two terms are used to convey different meanings, *simplification refers to the elimination of superfluous varieties, sizes, dimensions, etc.* It is essentially a reducing

[1] See L. P. Alford, *Cost and Production Handbook,* Ronald Press Company, New York, 1937, pp. 303–304.

process, a cutting down of varieties and types with relatively little regard for the use of any scientific procedures or methods. It may well be described as an empirical process. On the other hand, *standardization refers to the setting up of fixed sizes, types, qualities, measures, etc. Standardization implies careful consideration of relationships and values, usually involving scientific procedures.* Standardization generally involves a reduction in the number of sizes and types; however, it frequently requires the establishing of new sizes or types to take the place of some of those eliminated. Standardization is primarily an engineering function which has a direct influence upon commercial usage and practice. Simplification places less emphasis upon the engineering side of an enterprise and more upon the commercial aspects. Although the foregoing distinctions are stressed among certain students of production for the purpose of clarity in use, it must be conceded that others with considerable logic use the terms interchangeably. Professor Kimball defines simplification as "standardization in a limited number of particulars." [2]

A standard is a base line for management. The setting of standards thus becomes one of the fundamental tasks in organizing a business for operation. The value of standards as base lines is fourfold:

1. They create a foundation upon which other steps of good management may be built.
2. Establishing standards causes a careful investigation to be made into all phases of the business. Without such investigation standards cannot be intelligently set.
3. They tend to aid routine operation of the business and thus the development of a system and the application of the exception principle of management.
4. They reduce costs of operation in a way peculiar to themselves, thus making possible reduced costs to the ultimate consumer as well as increasing the profits of the business.

Frederick W. Taylor said:

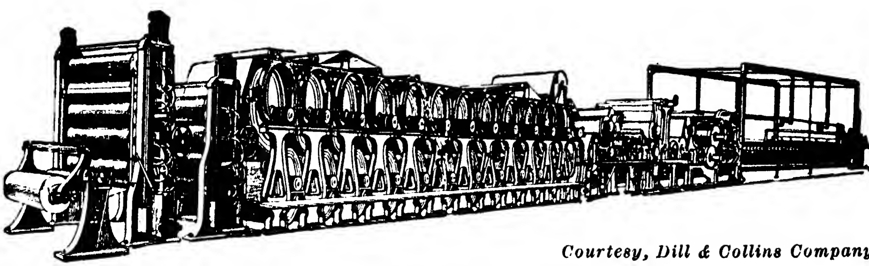
> It was in the course of making a series of experiments with various air-hardening tool steels with a view to adopting a standard for the Bethlehem works, that Mr. J. Maunsel White, together with the writer, discovered the Taylor-White process of treating tool steel, which marks a distinct improvement in the art. The fact that this improvement was made, not by the manufacturers of tool steel, but in the course of the adoption of standards, shows both the necessity and fruitfulness of methodical and careful investigation in the choice of much neglected details. . . . The economy to be gained through the adoption of uniform standards is hardly realized at all by the managers of this country.[3]

[2] Dexter S. Kimball, *Principles of Industrial Organization,* McGraw-Hill Book Company, New York, 1939, p. 283.

[3] Frederick W. Taylor, *Shop Management,* Harper and Brothers, New York, 1919 p. 124.

Pressure toward diversity of product. Unnecessary diversity of product has resulted from two main causes. The first is the demand of the consumer for products that are individually different, to meet either peculiar service needs or individual preferences of style and taste. The second, and wholly remediable cause, is that sales methods have frequently emphasized distinctiveness which calls for diversity in production.

Sales divisions, selling agents, and salesmen themselves all have felt that one of their strongest selling arguments was that a particular product was a novelty or that it was different from anything they or their competitors had before presented to the trade. In addition, they have frequently urged retailers to stock a huge variety of the product they sell on the basis of appealing to the consumer's desire for individuality. This practice has been frequently unnecessary and costly to the retailer.



Courtesy, Dill & Collins Company

FIG. 9.1. Fourdrinier machine.

The effects of product diversification on production. The American Writing Paper Company, studying the losses involved in this type of selling method, reduced their line from 2000 separate varieties of paper to approximately 200. Some of the production reasons for this change well illustrate the importance from a manufacturing standpoint of the standardization of product. The key machine in the industry, the paper-making or Fourdrinier machine, which is from 50 to 200 feet long (Fig. 9.1), must be stopped and started every time a new grade of paper is run through it. Not only must many time-consuming adjustments be made on the machine, but also there is a huge loss of material from wastage of paper as the machine is being finally adjusted. Frequently the down-time cost on the machine plus this wastage is sufficient to cause an addition to the cost of production of ten to fifteen per cent alone, when the runs of paper are short. In addition there are the losses incident to idleness of equipment which performs subsequent operations on the paper, these operations varying according to the type of paper being manufactured.

Advantages of simplification. The benefits accruing from simplification of the product include: lower unit cost, decrease in capital invested, lower labor cost, advance in the technique of production, improvement in equipment utilization and control, possibility of speedy and reliable delivery, improved quality of product arising from concentration of effort, and increased turnover of capital invested in inventories. Together these insure consumer satisfaction because of prompt service at low prices, in addition to greater profits on the same investment for the manufacturer.

A decrease in the capital investment is brought about through the utilization of less machinery and fewer tools, patterns, and other auxiliaries, as well as through the reduction in the inventories of raw material, parts, or partly worked material and finished stock. Lower labor costs come with familiarity of the workers with their more frequently repeated tasks, as well as with the steadiness of employment that follows the well-defined production programs that can be mapped out when the product is standardized. Increased stabilization of employment is one of the major benefits that will result from further simplification.

As the technique of production improves, intermittency in the use of equipment being eliminated, more expensive equipment better suited to the manufacture of the standard product can be bought, and cost reduction promptly follows simplification. Knowledge of the organization becomes specialized along narrower lines, and thus there is a tendency toward constant improvement of process. Simplification also results in production with less wastage of material. Not only can equipment especially suited to the product be procured, but also each type of equipment can be more easily assigned to the production of that portion of the product to which it is best suited.

Product standardization has all the advantages which have been claimed for simplification but to even a greater degree, both within the producing and selling organizations and in the broader socio-economic relationships of the consumers.

Securing simplification. Cooperation between the sales and production divisions, through regular committees or special conferences, is the first requirement in developing a workable program of product simplification. The development of a budget of sales and production, as explained in later chapters, is probably the best insurance of successful operation. If this is not practicable, each item of the line should be carefully gone over in the conference between the two departments, and the requirements of each division thoroughly understood by the other before items are either added or dropped from the line of products. Some of the means that have been utilized by individual industries to secure simplification

deserve mention. They include the revision of sales methods, the development of a succession of designs if novelty is an important factor, and the development of standardization of parts.

In changing over sales methods to effect simplification, *the change is from arguments based on diversity and price-shading to arguments based on* (1) *better goods at the same price* or *the same goods at a lower price* because of manufacturing economies; (2) *service to the customer;* and (3), if the product is sold through dealers, *quicker turnover* and hence lower investment, damage, and obsolescence charges. Such vital changes in selling methods at times necessitate changes in whole mechanisms of distribution.

Style and simplification. In highly styled items standardization over a period of years is an impossibility. In the woman's hat industry, despite the importance of novelty, taste, and style, much progress can be made in the standardization of texture of materials, as contrasted with design, and of the inner portions of the articles manufactured. Wherever possible, the addition of certain staple styles to the line does much to bring to the plant the benefits of standardization. In such industries advantage can be gained by insuring the elimination of designs of past seasons at the time that new designs are added, thus keeping the total line to a given number of patterns. This idea of *succession of designs* is very important in all industries where taste and novelty enter into retail sales.

Standardization of parts. In mass-production industries parts standardization may be secured to a large measure even if these parts are assembled into a variety of products. Such a program is followed in shoes, automobiles, furniture, and stoves. The experience of a large stove manufacturer clearly illustrates this step in standardization. The first items standardized were stove lids and stove centers, the crosspieces that hold the lids in place. There are from four to six of these on every stove, and the old method of making them was to have a different size cover for every stove. All types were abandoned except one, which was made in 7-, 8-, and 9-inch sizes, thereby eliminating many patterns and much of the stock of castings. Next, the legs of the stoves were standardized; they were made in four classes, light legs and heavy legs, with and without base strips. These four types were substituted for the great variety that had previously existed. The bodies of ranges and cookstoves were next developed so that they could either be trimmed with many nickeled parts or left untrimmed, allowing three grades of stoves to be made from one size of body. Many auxiliaries, such as towel rods, swing shelves, lifters, and handles, were standardized for practically all types of stoves.

The automotive industry has been able to standardize largely in the

manufacture of parts. Absolute standardization of the finished product has proved to be impossible for any factory, because of varying consumer demands for size, price, type of body, and color. Through the Society of Automotive Engineers the automotive industry has led the country in developing standard specifications for bolts, screws, sheet steel, and other component parts.

In some very complicated industries standardization has been achieved through the leadership of one company. Thus in the pipe fittings and valve industry the Walworth Company took a very conspicuous part in working toward simplification. It announced the elimination of 4½-, 7-, 9-, 11-, 15-, and 22-inch fittings and valves. Other manufacturers followed this lead in the elimination of excess variety.

The standardization movement. The War Industries Board (1917–1918) facilitated the World War I effort and made a lasting contribution to industry. An illustration of the enormous reductions in variety of product which were brought about under the leadership of this board is the reduction in the number of colors of men's hats to 9, as compared with approximately 100 distinct colors that several factories were previously producing. Another example is the reduction of rear gearings of farm tractors from 1736 to 16. Action in the industries closely allied with war operations was quickly followed by action in numerous other industries with a view to general conservation of plant capacity, materials, and manpower.

Simplification within an industry is essentially a cooperative action, because one large company selling on the basis of diversity can make standardization very difficult for its competitors. The United States Chamber of Commerce, observing this fact and seeing the advantages of simplification, undertook an educational campaign through its Fabricated Production Division in 1920, organizing a movement which brought prompt results. In 1921 the Division of Simplified Practice of the United States Department of Commerce was formed, and the United States Chamber of Commerce turned over to this new governmental agency the sponsorship of the movement.

The Simplified Practice Division has had the assistance of an advisory group, highly representative of industry and including representation from the United States Chamber of Commerce. The first step in the program is a survey of the industry, conducted by the trade, to determine the number of current varieties and the demand for each one. The results are studied by a simplified-practice committee appointed by the industry concerned. A tentative program of elimination is formulated for presentation at a general conference composed not alone of producers and distributors but also of consumers and neutral engineers. After formal

acceptance of the recommendations by a substantial majority of interested groups and individuals, they are published by the department as one of the series of simplified-practice recommendations, subject to periodic revision either by another general conference or by a standing joint committee of the industry. One manufacturer alone can do little toward standardization unless he dominates the field. A trade association which interests all its members in this subject, establishes standards, and works in conjunction with the associations of allied trades can do much to promote standardization.

Preferred numbers. The system of preferred numbers in standardization sets up a series of values, each of which is greater than the preceding one by a constant percentage. It appears that man prefers a series advancing by a geometric ratio to the arithmetic progression.[4] Eidmann points out that many of the sizes established empirically closely approximate the preferred-number series. After nearly ten years of study and revision the American Standards Association approved a system of preferred numbers in 1936.[5]

The preferred-number series takes 1 or 10 as the base and multiplies each successive number in the series by a constant percentage. When the series is less than 1.0, the values are determined by dividing the series between 1 and 10 by 10, 100, etc. The respective series most commonly used have their constants derived as follows:

Series 5: $\sqrt[5]{10}$ or 1.5849

Series 10: $\sqrt[10]{10}$ or 1.2589

Series 20: $\sqrt[20]{10}$ or 1.1220

Series 40: $\sqrt[40]{10}$ or 1.0592

Series 80: $\sqrt[80]{10}$ or 1.029

An inspection of this tabulation shows that series 5 has 5 uniform steps of approximately 60 per cent between 1 and 10; series 10 has 10 steps of approximately 25 per cent; series 20 has 20 steps of approximately 12 per cent; series 40 has 40 steps of approximately 6 per cent; and series 80 has 80 steps of approximately 3 per cent.

The use of preferred numbers in determining sizes and dimensions facilitates standardization, especially when supported by the trade asso-

[4] See Frank L. Eidmann, *Economic Control of Engineering and Manufacturing*, McGraw-Hill Book Company, New York, 1931, pp. 268–297.

[5] See Bernard Lester, *Applied Economics for Engineers*, John Wiley and Sons, New York, 1939, p. 129.

ciation of an industry. Without concerted action, individual manufacturers might well select different series as a base.

Economies can be realized in design and manufacturing in the long run if industry will seriously undertake the adoption of preferred numbers as a base for standardization. The most important advantage of preferred numbers will accrue to the purchasers and users in such items as gauges, in sizes of materials, in over-all dimensions of machines, apparatus, and articles of all kinds, in ratings, in commercial capacities, in speeds. In other words, preferred numbers tend to promote the interchangeability of goods made by different manufacturers.

Effect of standardization of the product upon the worker. The change in type of workman with the standardization of product is significant. As operations become automatic and repetitive, they can readily be performed by persons of less skill, even in machine operation. There can be no question that the development of standardization means the introduction of automatic machinery to perform the operations in the manufacture of the standard product. The usual result, however, is not the degradation of the skilled workman but rather the elevation of the unskilled man into a semiskilled job. Standardized products mean cheaper products. Markets are expanded, luxuries become necessities, and jobs are created for many more persons through product standardization.[6]

Mechanization incident to product standardization is but a small step in the progress of the transfer of workers' skills, which started with the very beginnings of the Industrial Revolution. Industries manufacturing diversified products must mechanize almost as fully as those making standard products. The use of process conveyors is not dependent upon the production of only a few sizes of products.

Another objection to product standardization is that it kills the worker's initiative. By working on the same task day after day, however, a man really knows the job and the machine better than the person who first developed them. He knows enough really to make suggestions that are practical and can be utilized. The man who, working on the same task day in and day out, cannot find play for his initiative in suggesting improvements, has no initiative. There is a problem in insuring that the worker realizes his relationship to the industry as a whole, but that is true of division of labor under modern conditions regardless of standardization.

There is one final answer to the objections. The tasks of a very large share of workers in industries are so constructed that they do not change

[6] See the article, "Skill," by Anna Bezanson, in *Quarterly Journal of Economics*, August, 1922. This article is just as pertinent today as the day it was written.

whether the product is standardized or diversified. To the man working around the dye vat in the hat factory it makes little difference whether hats are made in a hundred or in nine colors. His task remains the same, and the technique of his job is not affected.

STANDARDIZATION OF MATERIALS

Standard materials. It is impossible for production problems to be readily solved if the material that is being worked upon is not standard or if its composition is not definitely known. Naturally, it is not necessary that the best material be purchased. This would force all products to be high-grade and afford no goods for those with low purchasing power. Therefore standardization of materials takes the form of type standardization, not necessarily the most costly type but that best suited to manufacturing conditions.

An outstanding characteristic of the use of standard material is the factor of reliability or certainty. Absolute reliability or certainty is not practical, but reasonable manufacturing reliability is both practical and economical. The product engineer specifies certain qualities to be desired in the material used and can predict the performance of his product with assurance.

The standardization of raw materials directly affects the operation of several branches of any manufacturing enterprise, such as the following:

1. The product-engineering department.
2. The materials engineer.
3. The purchasing department.
4. The methods department.
5. The production-control department.
6. The time-study department.
7. The manufacturing departments.
8. The cost department.
9. The salvage department.
10. The inspection department.

Standardized materials and the product engineer. The tire-design engineer may call for a long staple sea-island cotton of a certain specification and rely implicitly upon its strength. The tensile strength of this fabric of a given specification has been established as a result of literally thousands of breaking tests in the laboratory. If the fabric should not be of the required standard, because of a different twist, shorter staple, or exposure to some chemical, the unaided eye might fail to detect the difference; but the strength would be reduced and the tire-design engineer's careful work would be largely wasted. It is because of such situations that materials are tested at great expense. As a matter of fact, in

modern tire construction the design engineer realizes that his work is largely futile unless standardized materials are used. The same principle holds for machine construction, building construction where strength is a factor, and in many other types of production.

The quality control or materials engineer. In some industries the materials engineer is a functional officer, sometimes called the quality-control engineer. He may be attached to the product-engineering department, the purchasing department, the research department. He usually has a dual function—(1) to be on the alert for new materials that may be substituted for those now in use, either as a matter of reducing costs or improving the product, and (2) to check the quality and use of present materials. When the second function is of prime consideration, he may be attached to the inspection department or the purchasing department. If he is attached to the inspection department, his influence will be relatively slight. The quality-control engineer devotes most of his time to procedures requiring chemical or technical ability, not to routine operational inspection. If he is attached to the purchasing department, he will act as an adviser not only to the purchasing department but also to other departments, especially with respect to new materials. New products are constantly being marketed, particularly in the chemical and plastics industries. The materials engineer may well be in a position to suggest to the product engineer and others substitute materials that are better adapted to the requirements of the product or the manufacturing process.

The purchasing department. If the materials bought are standard, the purchasing department is better able to keep abreast of market conditions, to place large orders, and thereby to receive lower prices and larger discounts. It is also better able to keep in touch with the demands of the factory for raw material and hence to lessen the likelihood of a partial shutdown because certain raw material is not available. As a result of research on the part of individual corporations, trade associations, and the federal government, a great mass of data has been accumulated on various materials. Much of this information has been formulated into recognized standards which are available to the purchasing department. These standards for materials simplify the work of the purchasing agent. Purchasing agents have taken an active part in establishing standards for materials used directly in the product as well as for supplies.

The methods department and material standards. It is not at all infrequent for the design to be modified at the suggestion of the methods department to simplify its production or to make use of standard materials already in use in the plant. The methods department is interested

not only in standard materials as a means of simplifying operations, but also in making use of available equipment.

The manufacturing division. When materials do not run true to form, much additional labor is required. When the sheet metal draws properly for the fenders, the metal finishers can keep up their end of the work and are usually satisfied with their earnings. When ten per cent additional labor is required because of ripples in the metal, the metal finishers cannot meet standards, and production falls behind schedule. The same situation applies to all other operations. Any irregularity resulting in below-standard material usually requires additional labor and not infrequently increases the normal scrap from operations.

The motion- and time-study department. Standardization is essential if motion and time study is to be fruitful. Standardized operations must be adopted before time values can be established. Standardization of operations can be attained only when both material and machines are standardized, at least to a workable degree. When standards are set for a given material, they are presumed to hold until the method is changed. If the material falls below the standard set, the method has to be changed, thus immediately destroying the standard. This breeds ill will on the part of the employees and tends to vitiate the work of the time-study men. There is no agency in manufacturing more vitally interested in establishing and maintaining workable standards for material than the motion- and time-study department.

Standard material and production planning and control. There can be no such thing as scientific production control in the absence of reasonably standardized material. Even in a job-order plant making products that are not standard in their entirety, a large part of the work is standard. If it were not so, production control would be impracticable. By having the desired material available when needed and by following carefully a logical sequence of operations, production control reduces the size of the inventory of raw materials to be kept on hand, reduces the inventory of work in process, increases total output, and makes possible the meeting of promised shipping dates. Adequate materials of the proper specifications are a vital necessity to proper production control.

Cost predetermination.[7] Standardized materials and processes are an integral part of standard costs so widely used in industry. Although it is probably an exaggeration to say that standard costs could not be used without accurate maintenance of material standards, it is true that the use of standard costs under such a situation would be largely ineffective. Standard costs are built upon a theoretically desired standard that is

[7] See Chapter 30 for a discussion of standard costs as a medium of control.

capable of attainment under practical operation conditions. In turn, standard costs provide management an excellent means of control. Any deviation from the standard of materials used will tend to produce a deviation from the standard costs. If the standards are right, to use substandard materials will tend to raise labor costs and thus in the long run either increase the selling price or reduce profits.

Material standards and the inspection department. The primary activity of the inspection department is checking the quality of raw materials, work in process, and the finished product against established standards. The inspection department plays an important role in quality maintenance, even though the manufacturing department is basically responsible for quality. This department tests materials as they come in and as they are progressively processed throughout the plant. Quality can be secured in the absence of standard materials, but as has been pointed out, the cost of maintaining this desired quality in the finished product is high.

United States Bureau of Standards. The United States Bureau of Standards makes thousands of materials tests yearly, many of them at the direct request of the manufacturers. In order to promote wide use of the results of these tests, the Bureau has adopted a so-called "certification plan." The Bureau compiles lists of manufacturers who have expressed their desire to supply material in accordance with certain specifications and who are willing to certify to the purchaser that the material thus supplied complies with the requirements and tests of these specifications. This is an extension of the service which the Bureau of Standards has furnished for some years to government departments. Materials which are supposed to meet such specifications, if purchased by a company without its own laboratory, may be checked easily by submission to a commercial testing laboratory, for the specification is standard. To the extent that the certification plan results in the standardization of commodities, its benefits are felt by all material users, whether or not they directly use the certified specifications. For some years some commodities, for instance, lumber, have been marked with the standard grade of an association, as the American Lumber Standards.

The American Engineering Standards Committee. This committee, with offices in New York, is a creation of the several technical societies, such as the American Society of Mechanical Engineers, the American Society for Testing Materials, and the Society of Automotive Engineers; a number of trade associations, such as the National Electric Light Association, the American Gas Association, and the American Railway Association; and a number of other groups interested in industrial standards, such as the National Safety Council, and the Bureau of Casualty and Surety Underwriters.

The purpose of the American Engineering Standards Committee is to develop standards for industry through mutual action. When a particular type of standard is to be developed, a subcommittee is formed, with representation from all those interested in the proposed standard. Among those who receive such representation are the engineering society interested, manufacturers of the article, users of the article, and labor. The final report made by this sectional committee is reviewed by the executive committee of the American Engineering Standards Committee and, if finally approved, is adopted as the American standard.

Standards may be changed. One of the advantages of material standards is the stability that they give to manufacturing processes, yet they are not static. The uninformed frequently argue against standardization, claiming that it retards progress. As a matter of fact, standardization under the ancient guilds did retard progress, but this criticism is no longer valid. Businessmen in the United States are eager to improve the quality of their products. They have led the world in standardization, a fact which in part accounts for their leadership in industrial production. With a genuine improvement in the quality of an item, the standard usually is changed to incorporate the improvement.

The National Bureau of Standards has had wide experience in observing changes in specifications and has listed the following qualities as desirable for specifications: [8]

1. They must be definite in nature and free from clauses which require an expression of opinion by the inspector.
2. They must be limited to the essential qualities of the product or material under consideration. The specification of unessential qualities may raise the cost of the product and certainly increases the time required for testing.
3. The qualities specified must be capable of measurement.
4. The specifications must be supported by a definite statement of test methods in order to avoid quibbling about the methods of testing used.

[8] Adapted from "Services of the National Bureau of Standards to the Consumer" (not dated), p. 5.

CHAPTER 10

PROCESSES AND MATERIALS

The consumer of materials, whether he is a primary or a secondary manufacturer, has at his command the findings of the laboratories of his vendors, the findings of scientific societies, and information on materials and processes which originated in hundreds of commercial and university laboratories and in the minds of thousands of scientists in every industrial country on earth. The accumulated body of knowledge which has developed in recent decades is the basis for most of the manufacturing technique of today.

A change in manufacturing procedure usually involves a major decision by management, since it involves large expenditures in new equipment, changes in customer relationships, and at times fundamental changes in the structure of the organization necessary to manufacture and market the product. The development of a product is linked inseparably with the availability of certain manufacturing processes and the materials of correct characteristics at the right price, as well as the availability of machines to produce the desired quality of goods at a profit.

Research and production. Almost overnight steelmakers found that their methods of producing steel sheets and strip had been made obsolete and that, if they desired to participate in that portion of the steel business which was beginning to yield the largest tonnage and at the same time show the greatest profit, it would be necessary for them to install wide, continuous-type mills. These mills, now developed to roll sheets up to 96 inches wide continuously, that is, with no back tracking of the material or transfer to other mechanisms, cost from $6,000,000 to $15,000,000 to install. Since the automotive industry is the greatest user of the product of such mills, they have largely been located in states of the Great Lakes region.

Although in this discussion it has been assumed that the development of the continuous rolling mill was the starting factor of this chain of events, this is by no means true; this point was the starting factor only in the point of the origin of the material. For instance, the development of the welding process in industry made possible the fabrication of these sheets and thus caused a demand to be made upon the steel manufac-

turers for a greater quantity of large sheets, which in turn caused the spread of the continuous mill. Research in many branches of manufacturing, often carried on concurrently, creates a closed chain of events. It is difficult to find either the beginning or the end of the chain. Together, such research projects result in tremendous changes in manufacturing, great outlays for new materials and equipment, strains on the finances of the industrial companies least able to bear the burden of the outlays, and changes in the skills demanded of the working man, with

Courtesy, "Automotive Industries"

FIG. 10.1. A continuous-strip mill, Inland Steel Company, Indiana Harbor, Ind.

consequent changes of occupation and even in the location of manufacturing communities. For instance, the development of electric welding (Fig. 14.5, p. 207) made possible the use of the wide sheets of steel produced by the strip mills (see Fig. 10.1) to give the public the all-steel automobile body.

The possibility of securing wide sheets for body-building purposes revolutionized the processing of bodies in the automobile industry. Die-making machines became taxed to the utmost to produce the huge dies necessary to form one-piece tops (see Fig. 14.9, p. 212). The whole structure of the tool and die industry which had been developed to serve the automotive industry was disturbed by the sudden demands for huge dies of this type. Few die shops were capable of producing such dies, it was difficult to secure sufficient equipment from the machine manufacturers, and the finances of most of the tool and die shops, usually relatively small companies, would not permit the purchase of such equipment, even

if available. Thus much of the die equipment necessary to cope with the new demands was put into the plants of the large automobile manufacturers themselves, and they began producing a greater proportion of their own dies than they had made heretofore.

The press manufacturers were called upon to produce presses of previously unheard-of proportions (see Fig. 14.8, p. 211) to hold these dies and to stamp out body parts which were formerly made up of literally dozens of pieces. The triple-action press illustrated, which shapes sedan panels in one operation, has three moving slides to carry the dies. It is more than 25 feet high and weighs 600,000 pounds, necessitating the digging of a foundation 106 feet deep down to solid rock. Similar presses of a size previously unknown caused production problems for both the press manufacturers and the users until complete knowledge of their capabilities was developed from experience. But for the development of the other processes described in this sequence, no demand would have been created for such machines.

Steel alloys. The electric furnace made possible the development of a multitude of alloy steels at commercially feasible prices. For resistance to corrosion, chromium is the alloying element which produces a condition approaching perfection. The long series of "stainless steels" which have been developed resist the corrosive action of many chemical salts and acids as well as of the atmosphere. From tableware to stove and sink tops, from automobile trim to whole trains of stainless steel cars, chromium in varying alloy proportions is today making possible products designed from steel which are as attractive after years of use as the day that they leave the factory and which need no protective coating. During World War II, when chromium was exceedingly scarce, an entire series of NE (National Emergency) steels was developed. Chromium was still used but in much smaller quantities. These low chromium-nickel-molybdenum steels will continue to be used in peace but not in such quantities as during the war.

To add strength to steel, nickel has been the most widely used alloy. It has been combined with chromium where high-strength stainless steels are in demand and where cost can be figured in terms of long-run economy. Where there is a demand for ferrous alloys with high resistance to rust and corrosion but also with high strength, as in the chemical and food-processing industries, nickel steels are desirable. Nickel-manganese cast steels are important in structural parts of railroad cars, tractors, and power shovels, where ultimate strength is the important consideration. Common gray iron with nickel alloy has also proved to be a successful and, under many conditions, an economically proper material, fully able to compete with steel castings under conditions where stresses

are not too great. Within the last 10 years tremendous strides have been made in the manufacture of high-strength cast iron and cast steel.

For many years molybdenum was added to steels which required strength, hardness, or toughness at elevated temperatures of operation. In alloys this element imparts superior high-temperature properties to numerous working parts. With the clearer definition through the years of the results of proper manufacture of steels in the first instance and of heat-treating of steels after manufacture, there has been a constant tendency to reduce the percentage of alloys in the steels and hence to increase the range of their economic usefulness. With this attention to the problems concerned with the action of heat on metals has come a knowledge of the greater usefulness of molybdenum as an alloy. Plain carbon-molybdenum steel has proved most successful for deep-drawing steels and steels for high-temperature service. Chrome-nickel-molybdenum steel has now become a common alloy. This steel, with a high carbon content, is to be found in large forgings of many types and in high-temperature forging dies.

Among the many phenomenal developments in the steel industry has been the cold treatment of steel to hasten its aging or seasoning process. For years the manufacturers of steel gauges have known that tool steels do not attain a condition of stability for some time after hardening. Precision steel blocks undergo a stage of growth and distortion over a period of a few years. This distortion is from 10 to 20 times the permissible tolerances. To overcome this difficulty the semifinished gauges were exposed to outside temperatures for a few years before being finished. Experiments showed that bringing the high-speed steel down to a low temperature immediately after quenching stabilized the steel more completely and increased its hardness, strength, and ductility. By bringing the steel down to minus 100°F. the stabilization that formerly required several years could be achieved in 48 hours.[1]

Leaded steel, graphite steel, zirconium steel, nitrogen steel, silicon-impregnated steel, and many other steels for special use have been developed during the past few years.[2] Certain alloys of steel have made possible the development of the gas turbine. Nevertheless much work

[1] See Archibald Black, "Some Recent Developments in Engineering Material," *Mechanical Engineering,* February, March, and April, 1945, for an illuminating discussion of the many recent developments in ferrous metals, nonferrous metals, and nonmetals.

[2] This entire subject is highly technical and is understood only by the metallurgist. It is presented in this chapter as a matter of general information, not as a technical treatise. It is not recommended that the student try to remember the details of these various alloys.

still remains to be done in the development of a steel that can resist the high temperatures of the gas turbine before this efficient source of motive power can be fully utilized.

Tools and dies. The manufacture of steel for tools and dies has long been one phase of the steel industry to which much research has been devoted. Its economic significance has been possibly the most important in the industry, particularly in relation to displacement of labor by machines and in its effect on the machinery industry, in that significant changes in the nature and design of machinery are indicated in order to take full advantage of the newer tool steels. The long and careful research of Frederick W. Taylor and J. Maunsel White just before 1900 at the Bethlehem Steel Company resulted in the development of "high-speed steel," the first significant improvement on older carbon steels used for cutting metals. It was not only the alloy composition of this steel but also the carefully developed method of heat-treating it which made it stand apart from all other metal-cutting materials and caused production increases of 400 to 500 per cent with the same machines and equipment. Increased production was aided by the proper utilization of the fast-developing body of knowledge concerning methods of sharpening these tools (see Chapter 14). This high-speed steel had the ability to stand up when run at speeds that heated the tool red-hot.

During the decade between 1920 and 1930 much of the work was done which produced a diverse series of special-purpose tool steels. One of the first special steels to be introduced, still utilized on a large scale, was Haynes Stellite, a cobalt-chromium-tungsten alloy, which, like high-speed steel, maintained its properties at red heat. It machined at high speeds cast iron, malleable iron, and semisteel and could be profitable used on certain grades of steel. Toward the close of the decade there were developed first in Germany and later in the United States a number of tungsten-carbide cutting tools, of which the best known is Carboloy. These new cutting tools at first had limited applications, giving extremely rapid speeds of cut on light feeds for continuous cuts, as on lathes, but cracking or shattering on other types of cutting operations and failing on heavy work. Gradual development obviated most of these difficulties, and this series of cutting tools soon necessitated the virtual redesign of numerous machine tools in order to provide for the stresses which their high speeds set up. Because of the high value of the material these tools consist of small tips of alloy welded to steel shanks (see Fig. 14.16, p. 218). Recent developments in cutting tools have made it possible to remove some of the lighter alloys so fast that conveyors are required to carry away the cuttings.

Mr. Philip E. Bliss, former president of Warner & Swasey Company, manufacturers of machine tools, has said:

> With the new tungsten-carbide tools, a turret lathe of the same size as one built ten years ago is capable of removing twice as many cubic inches of metal in the same period of time. . . . A factory faced with the problem of doubling its output may, therefore . . . instead of doubling its floor space and equipment, keep its present floor space and replace its present metal-working equipment with machines of twice the speed and twice the productivity. . . . The result may be a new trend in factory building and factory rehabilitation—a trend in which compactness of operations and maximum productivity per unit of space may be the outstanding characteristics.[3]

For dies, special alloy tool steels have been developed which have increased productivity in equivalent ratio with the new cutting steels and at the same time permit longer operation of the presses on high-production runs without the necessary down time to change dies. Chromium-vanadium alloys have proved helpful in this development, as have the cobalt-chromium-tungsten alloys. Inasmuch as whole dies of any of these materials would be prohibitive in cost, once again welding has made a process commercially possible. The alloy is welded to the wearing parts of the die or is placed in the die in the form of inserts. At this point it may also be mentioned that similar wearing surfaces on many types of machinery and equipment are today protected by coatings, edges, or points of alloys in order to resist wear and abrasion. Among the products so protected may be mentioned automobile valve seats, plowshares, pug mill knives, clamshell bucket lips, shredder knives in paper mills, and steam valves.

Non-ferrous metals. Aluminum and copper, with its commoner alloys, brass and bronze, have come to be an integral part of the materials for our industries for many years, although it was 1886 before aluminum was first reduced by the electrolytic process and many years of experimentation followed before its price permitted its general use in those parts for which it was best fitted. Magnesium, a metal even lighter than aluminum, has been used on a considerable scale in materials where lightness is all important, as in the airplane industry. Aluminum, also often used because of its lightness, has excellent properties for conducting heat and has therefore been employed on a large scale in the manufacture of kitchen utensils and for cylinder heads in the automotive industry, to avoid the formation of hot spots above the cylinders in high-compression engines. Aluminum has come to be extensively used also in die castings, nickel being frequently added as a strength-imparting alloy. Beryllium is an expensive metal, but in small quantities it makes possible the heat-

[3] *Steel*, June 11, 1934, p. 46.

treating of certain metals, such as copper, lead, nickel, and silver. It has been used most commonly with copper. A beryllium-copper-edged tool can be used in situations where the sparks from a steel tool might produce a hazard, since the beryllium-copper alloy possesses nonsparking characteristics.[4] Porous-chromium surfacing makes possible the use of chromium surface in cylinder walls, piston rings, and similar items. Chromium has one of the lowest coefficients of friction of any of the metals, but smooth chromium will not retain a good oil film. By the Porous-Krome Process the wearing surface is made porous so that the oil film will be retained, thus giving a remarkably efficient surface in terms of low friction.[5] Copper and silver have both been used very successfully in brazing iron and steel. For some purposes silver is even better than copper, but its expense is generally prohibitive. The shearing strength of a properly made joint exceeds the shearing strength of the copper itself.

The laminating of metals has been developed to a state undreamed of 20 years ago. This process has been applied to nickel, Monel, Iconel, stainless steel, silver, and aluminum.

Monel metal, an alloy composed of approximately two-thirds nickel and slightly over one-quarter copper, with small portions of other metals, has become a household name in recent years because of its extensive use in kitchen equipment wherever resistance to rust and stains is an important factor. Its use has been somewhat retarded because it is relatively high-priced as a result of the large percentage of nickel which it contains and because of the concurrent rise of the stainless steels.

Plastics. Plastics are marketed under many trade names, such as Bakelite, Textolite, Cetec, Durez, and Tennite. The various plastics have many properties, which may be varied to meet different situations. Plastics as a group may be moulded or machined to meet many requirements. They are used extensively in the manufacture of radio cabinets, electrical controls, automobile steering wheels, gear-shift knobs, silent gears. Almost any color is available in plastics. They easily take a high finish and usually have considerable resistance to moisture and many acids. They usually possess a high ratio of strength to weight and may be produced to provide considerable resilience to absorb mechanical shocks.

No doubt plastics will play an important role in future industrial developments, but there is little likelihood that they will replace the well-known metals except for certain specialized uses.

Synthetic rubber is a popular name for rubber substitutes, but such substitutes are not exact chemical replicas of natural rubber. The five

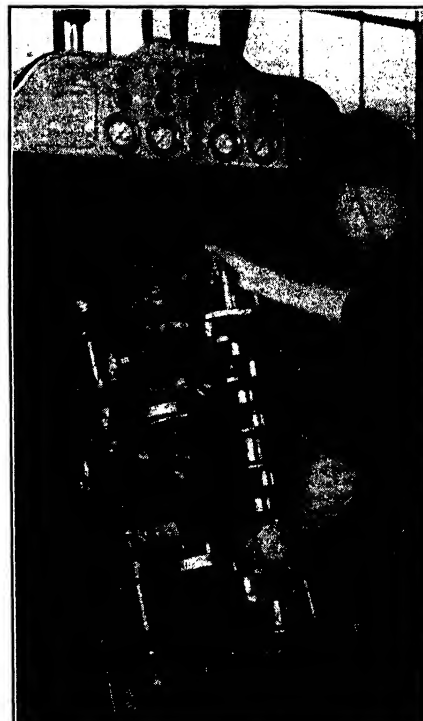
[4] See Archibald Black, *op. cit.*, March, 1945, p. 192.

[5] *Ibid.*, p. 193.

most common rubber substitutes, with the dates of their commercial introduction, are as follows: Thiokol, 1929–1930; Neoprene, 1931–1932; Buna-S, 1937; Buna-N, 1937; and Butyl, 1940. Synthetic rubber proved invaluable for the United Nations during World War II and has appealed to the imagination of the American people. Such rubber possesses certain characteristics that make it superior to natural rubber for some uses. It is to be hoped that an enlightened governmental policy will encourage further development in this field.

Both rayon and nylon are synthetic products that have exerted a profound influence upon textile industry. Rayon has been successfully used in automobile tires. The full industrial potentiality of nylon has not yet been exploited, but this substance has already made a place for itself in the manufacture of ladies' hosiery.

The various combinations of plastics, fiber glass, and other materials are almost limitless. Traveling bags, ladies' handbags, canoes, refrigerators, radio cabinets, bathroom units, upholstering materials, and other items have been made from plastics.



Courtesy, Ohio Crankshaft Company

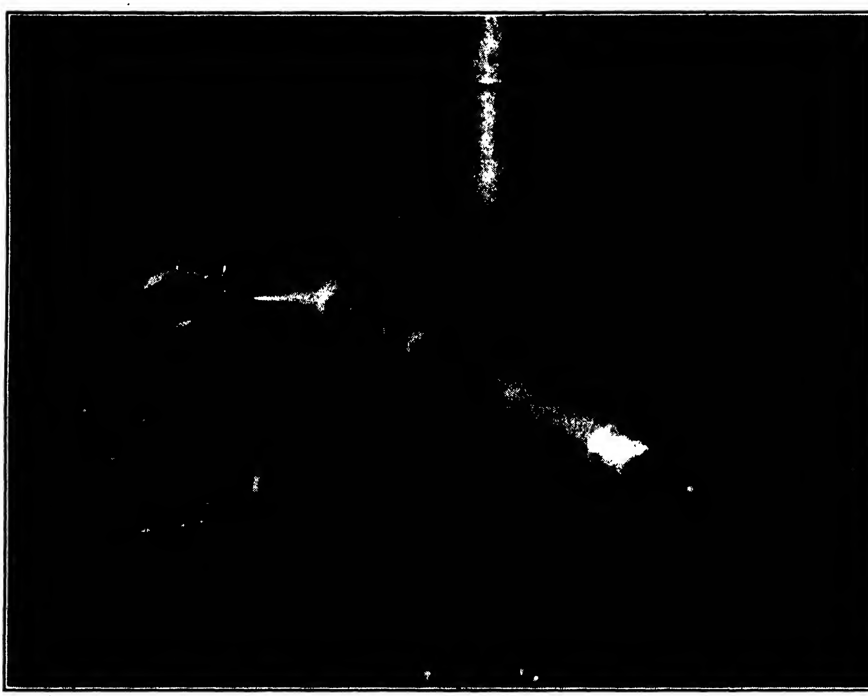
FIG. 10.2. Tocco process of hardening the bearing surfaces of a crankshaft in a few seconds.

Some relatively new developments. In addition to the items already discussed many others should be mentioned in passing. The production in Texas of magnesium from sea water has reduced the price of magnesium, thus making it commercially available for light-metal alloys. Resin bonding agents make it possible to bond metal to wood and other products.

Induction heating (high-frequency equipment) has achieved importance in commercial applications, such as heating bar stock for forging, heat-treating bearing surfaces (Fig. 10.2), brazing with copper or silver, melting of metals, compression molding of plastics, and brazing of cutting

edges on tools. This field of activity can readily be expanded. Figures 10.3 and 10.4 show two interesting developments in the use of electricity.

The oxyacetylene cutting process, which has been used for years, had wide application during the war in shipbuilding. It is also used extensively in cutting parts for machinery manufacture.



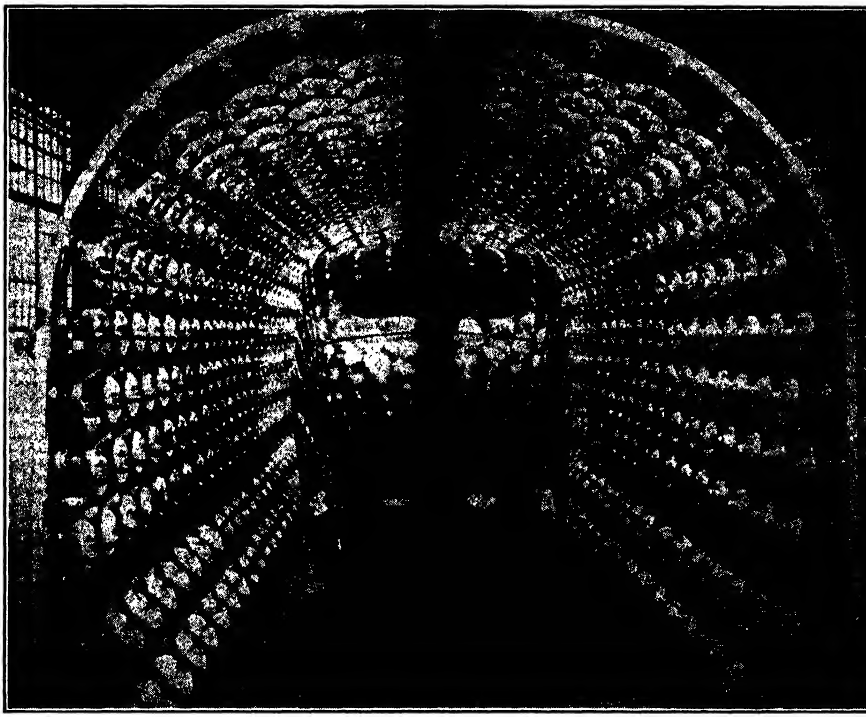
Courtesy, Metallizing Company of America

FIG. 10.3. Mogul metallizing gun spraying molten stainless steel for a protective coating on a paper roll.

The extrusion process is used extensively in the manufacture of metal and plastic tubing, rods, moulding, and irregular sections. In many cases a proper die produces a long piece of material that can then be cut to desired lengths to obtain parts that would be difficult to produce any other way. The extrusion process is not new. It was used in rubber manufacture forty-five years ago, but its wide application in the metal industry is relatively recent.

Shot-peening has been extensively used to reduce fatigue failure of springs, small parts, and castings. The electrolytic process of tin plating, which has been extensively used in place of the old dipping process, conserves tin and yields a more uniform product.

In the making of castings three developments have recently received additional attention: (1) powder moulding, (2) centrifugal casting, (3) precision casting in plaster investment moulds. Powder metallurgy, as applied to castings, consists in placing the desired powder in a mould under pressure with heat to give the desired casting. The metal powder



Courtesy, North American Electric Lamp Company and the Ford Motor Company

FIG. 10.4. Drying the finish of an automobile body by infra-red rays.

may consist of alloys or any other desired mixture.[6] Unusual forms may be secured. The casting is very accurate in comparison with the old sand castings; hence very little machining is required. Centrifugal casting, as its name implies, is accomplished by rotating the mould while the metal is being poured.[7] By this process a better texture of the metal and unusual forms may be secured. Precision investment or "lost-wax" casting consists in moulding a wax pattern for each individual casting, forming

[6] See Earle E. Schumacher and Alexander G. Souden, "Powder Metallurgy," *Metals and Alloys,* November, 1944, pp. 1327–1339, for an excellent discussion.

[7] See Gerald E. Stedman, "Unique Centrifugal Steel Casting Method," *Metals and Alloys,* November, 1944, pp. 1311–1315.

around the wax pattern a plaster cast of some refractory material, heating the plaster cast to flow out the wax, and pouring molten metal into the plaster cast. The wax pattern is moulded in a split-section master mould from a replica or model of the casting; hence it is very accurate in dimensions. A new investment (coat of plaster, aromic, or other castable material) has to be made for each casting. The casting of the liquid metal may be made under pressure, by the centrifugal method, in a vacuum or by ordinary pouring. Tolerances of ± 0.003 inch have been attained by this method.[8]

Special production tools. Coupled with new machine capacities and new productive capabilities of the alloy tool steels has been the development of tool design to produce special cutting tools which result in tremendous savings. The machining of a clutch housing is illustrative. The former method of operation included:

1. Milling the lugs for locating points.
2. Rough grinding the under surface of the housing.
3. Machining the interior of the housing in five separate machine operations.

The present method is to utilize one specially designed cutter, which, because it combines all the machining operations, eliminates the necessity for locating points and hence the milling process. Because of the greater capacity of the special tool, the rough-grinding process has been reduced in length from 6 minutes to 1.8 minutes per piece. The five separate machine operations have of course been replaced by the one that utilizes the special cutter. The old operations took 22 minutes in machine time alone, without considering handling time between operations or the necessary preparatory and planning steps. The job is now done with one grinding operation of 1.8 minutes and one cutting operation of 6.32 minutes, a clear saving of 13.88 minutes per piece in machine time.

Heat-treating. Progress in the heat-treating of metals has coincided with the development of alloys to produce materials which are easily machinable, the final product having properties quite different from those of the metal at the time that it is machined. Heat-treating also produces in a metal certain desirable conditions and properties which have no relation to its work ability. Heat-treating includes quenching by immersion in liquids or gases; hardening, or heating and quenching from the critical temperature at which the molecules of metal are rearranged; annealing, or heating and then permitting slow cooling of the metal; case hardening, or heating the metal in contact with carbon, so that some of the carbon

[8] See Archibald Black, *op. cit.*, p. 195; see also Fred P. Peters, "Selecting Production Methods for Small Parts," *Metals and Alloys*, July, 1944, pp. 93. These are excellent articles.

will be absorbed by the surface of the metal, and then hardening further; and cyaniding, or heating the metal in contact with a cyanide salt, followed by quenching. Effective heat-treating in industry has become possible through the development of temperature-control devices which provide proper temperature relationships throughout the heating cycle or in the quenching bath. These instruments have become the key to successful heat-treating. Distortion in hardening is now controlled through a more thorough understanding of the heat-treating process and a consequent design of parts to prevent such distortion. Research into heat-treating problems has proved to be particularly helpful in correcting material conditions traceable to previous processes and at times to steel-making itself.

Die casting. Decorative effects which can be produced cheaply by die casting have caused this process to advance rapidly as consumers have demanded better-looking as well as more useful products. Both zinc and aluminum alloys can be readily die cast. Although some resistance to stress can be developed in a die casting through the addition of such an alloy as nickel, in the main it is the smooth finish resulting from the process and eliminating any need for machining which has caused its application to the making of intricate designs intended for decorative effect (see Fig. 14.7, p. 210).

A feature peculiar to die casting is that it permits making as a single unit a product or component which otherwise would have to be composed of a number of individual units, joined by welding or some other fastening method. Inasmuch as the die-casting operation in its simplest terms involves merely flowing metal into a die under pressure and keeping it there the time required for it to solidify, the most modern die-casting machines are almost wholly automatic in their operation. The worker need only remove the finished piece from the die, so that costs are reduced by this process. Elaborate designs may require the operator to insert cores or steel parts. The design and composition of the steel die are easily seen to be the vital factors of this operation, and the intricacy of the finished product is limited only by the ability of the die makers to produce practical dies. Die castings find some competition from moulded plastics, an important industrial material referred to earlier in this chapter, but are also used to some extent in conjunction with plastics, as in grocery scales, where the die casting may form the structural part of the device and the plastic the moulded casing.

Welding. Welding is probably one of the most important industrial processes that have been developed during the twentieth century. Its ramifications reach into every industry, and its products are to be found everywhere. In welding metals are united by one of two general methods:

(1) plastic processes, in which pressure and heat produce the weld, and (2) fusion processes, in which the application of heat to the metal without pressure makes the weld.

From a practical standpoint most plastic welding done in manufacturing today is resistance welding; that is, the heat is produced by the passage of electric current through the parts to be joined. Such welding is referred to by a variety of designations, depending upon variations of the process employed; some of these terms are butt, flash, spot, seam, and shot welding. Butt and flash welding are used to join the ends or sides of tubes, bars, sheets, or similar parts in raw or partly finished condition. In butt welding the pieces are pressed together, and an electric current is passed from one piece to the other, causing a slight melting at the ends and a resulting union of the two pieces. In flash welding, used particularly for welding sheets and stamped parts, the pieces are drawn apart slightly after the current has been applied, and the resulting arc fuses the surfaces to be joined. Pressure is then applied to complete the union. Many specialized machines have been developed to produce welded parts by the flash-welding process (see Fig. 14.5, p. 207). Spot welding utilizes welding equipment with two electrodes on opposite sides of the pieces to be joined. As current flows through the pieces, it heats the area immediately between the electrodes to welding temperatures, the pieces being joined by pressure applied by the machine through the electrodes. This process is used to weld small stamped parts to large ones, for instance, bolt holders to enameling sheets in stove manufacture. It is a very rapid operation, for, if proper fixtures are supplied, dozens of spot welds can be made in a minute. Seam welding is a modification of spot welding, used when continuous seams are desired between the metals to be fused, the electrodes being wheels that roll over the surface of the metal being welded. A modification of the seam-welding process is used in automatic welding machines employed in the manufacture of welded steel pipe, which is made from coiled strip steel, run over a series of rollers, thereby bent into pipe form, and then welded. Shot welding is a specialized type of resistance welding developed and patented by one large manufacturer of welded equipment, the E. G. Budd Manufacturing Company of Philadelphia.

The most popular fusion processes of welding are the electric-arc atomic-hydrogen and the oxyacetylene methods. In addition to production work these processes are used in portable apparatus for making repairs on machines and equipment. In the electric-arc process either metal-arc or carbon-arc methods may be utilized. In metal-arc welding the current passes from a metal rod to the work. The heat of the arc causes melting of the edges of the work and the rod, so that molten metal

from the rod is deposited on the work, causing the fusion. In the carbon-arc process an arc is formed between a carbon electrode and the work, metal being deposited upon the work from a welding rod held in the arc. Large plates, large pipes, and tanks are welded mainly by the electric-arc process. Oxyacetylene welding utilizes a flame produced by burning a mixture of oxygen and acetylene in a blowpipe. This flame can combine a wide variety of metals of different grades and characteristics. At times a welding rod, which melts at lower points than the metals being fused, is advantageous in welding several metals of diverse physical characteristics. The oxyacetylene-welding flame can be made to have an oxidizing effect by increasing, or a reducing effect by decreasing, the amount of oxygen in relation to the acetylene. This flame is most valuable in welding metals of varying characteristics, the reducing effect being particularly desirable in welding rolled sections to castings.

As a result of the development of surface finishes, together with the improvement in steel-stamping processes, welding can be used to give the industrial designer, the manufacturer, and the consumer modern products with pleasing streamlined effects, in which rounded corners and the absence of seams are most important.

Electric control devices. Behind the fully automatic and semiautomatic machines of today must be the devices which give them their automaticity. Some of this automaticity is attained through perfection of machine design, including cam arrangement, and some has been achieved by hydraulic and pneumatic means, but by far the largest part has come from electric controls. The machines are ordinarily actuated by the electric motors applied to them, which in turn are controlled by intricate devices, timed to provide a means for bringing into play each function of the machine at just the right time in relation to every other function. The solenoid coil forms the basis of operation of many of these control devices. Other electrical developments which have come to have general industrial significance are the photoelectric cell and the vacuum tube.[9] The photoelectric cell is of particular importance in controlling colors of product; the vacuum tube has been utilized in many types of control, such as recording the moisture content in the manufacture of paper. In this control a rayon ribbon stretched across a tube and held just above the paper going through the machine becomes longer or shorter, depending upon the moisture in the paper. A radio measuring device in the tube transmits these changes in length to a meter, which can easily be read by the machine operator; he then makes any indicated adjustments to bring the moisture content to normal.

[9] See Keith Henney, *Electron Tubes in Industry,* McGraw-Hill Book Company, New York, 1937, p. 498.

Courtesy, Allis-Chalmers Manufacturing Company

FIG. 10.5. With a pyrometer a woman performs an operation for which a man formerly required years of experience to qualify.

Figure 10.5 shows a woman using a pyrometer to check the heat of molten metal. Formerly this function depended solely on the skill of the workman. Today science has established techniques far more reliable than the most skilled worker.

CHAPTER 11

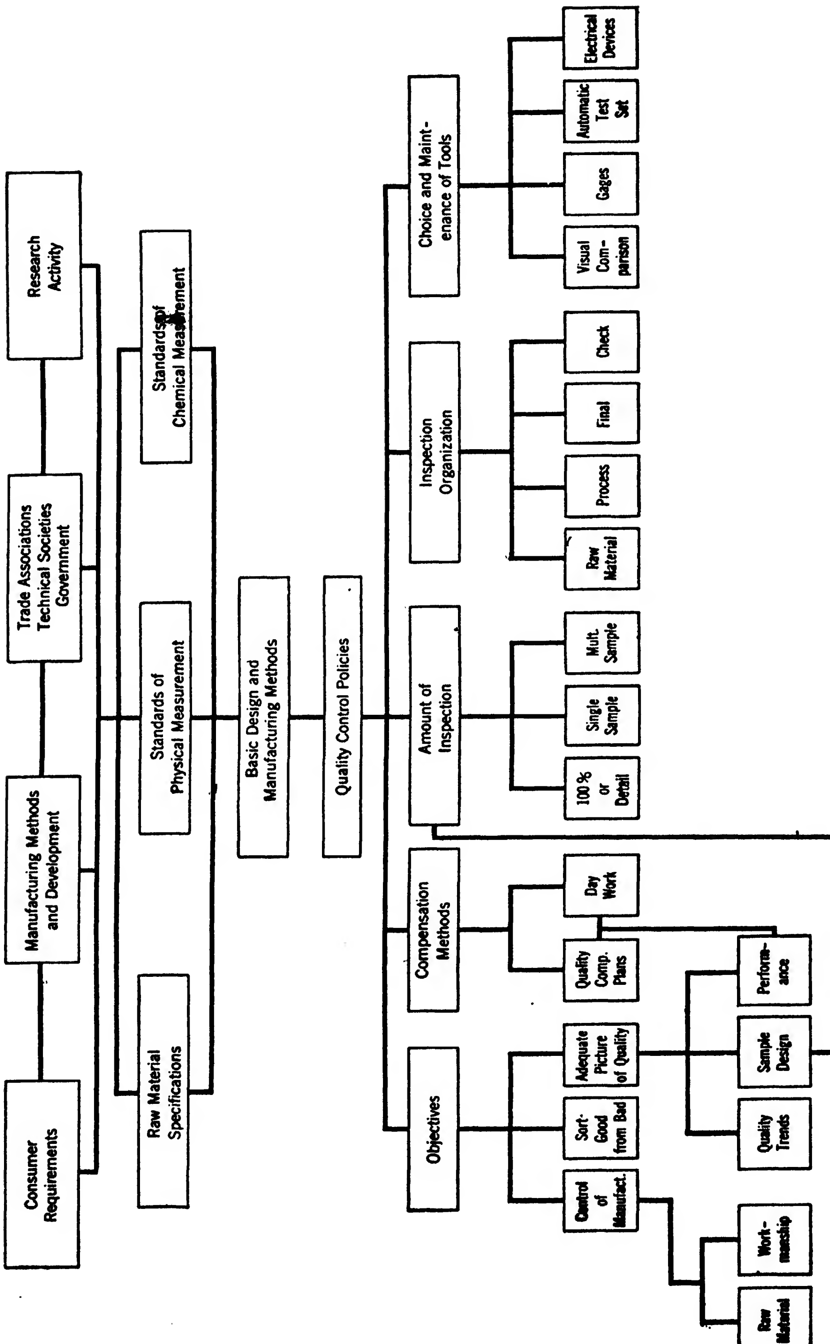
INSPECTION

Functions of the inspection department. Inspection is a control function. Relatively few persons like to be checked in their work; hence it is important that the objectives of inspection be made clear to all parties concerned, or unnecessary frictions tend to develop. The major objectives of the inspection department are as follows:

1. To control the quality standards of the manufacturing processes, *operative inspection.*
2. To aid in the location of the causes of defective work and cooperatively to assist in removing these causes, *preventive inspection.*
3. To sort acceptable from defective raw materials or work in process, *remedial inspection.*
4. To provide management, through properly designed reports, with a picture of the quality of the product made, a statement of the quality of the raw materials received, and a measure of the efficiency of plant operations, which is often used as a basis of payment to the worker.

The control through *operative inspection* of quality standards in manufacturing checks on the workmanship of all operations in the plant. This control is particularly effective when aimed at preventing future difficulties. To cooperate with the manufacturing group in the location of the causes of defects and to aid in their removal are the highest types of *preventive inspection,* the ones that pay the largest returns on effort expended and the types that are becoming increasingly important in modern industry. The sorting out of defective work in process or finished products protects the good name of the concern, prevents further expenditure on defective parts that must be rejected later, and protects the customer in his purchase. *Remedial inspection* is a necessity in plant operations, but the amount of this type of inspection decreases in proportion to the effectiveness of preventive inspection. To reject raw materials before they are started in production is in reality a form of preventive inspection. The providing of accurate records of the quality of raw materials, work in process, and finished products gives management statistical data for guidance in operating control and policies.

Figure 11.1 graphically portrays the interrelationships of the various departments with the inspection department.



Courtesy, John D. Golder

FIG. 11.1. Chart showing the origin of quality control and factors considered in the effective use of quality control.

Quality defined. *Inspection consists of the measuring of the qualities of a product or service in terms of established standards.* These standards fix in measurable terms the qualities pertinent to a given type of serviceability of the product. The quality of a product may be defined as the *sum of a number of related characteristics, such as shape, dimensions, composition, strength, workmanship, adjustment, finish, and color.* It is obvious that standards of quality should be a matter of record wherever possible. If these characteristics are not capable of adequate expression, they should be illustrated by a sample of the product showing the desired qualities; the product being inspected may then be compared with the sample. It is not always easy to describe certain desired qualities, such as the abrasive resistance ability of a given tire-tread design. Description in terms of a standardized test, such as wearing a given amount when run at a predetermined speed for a certain length of time under a specified load on a particular describable abrasive track wheel, may be required.

Types of inspection. Inspection may be classified under at least four different headings, depending largely upon the point of view or emphasis at the time of classifying:

1. Remedial and preventive inspection.
2. Centralized and floor inspection, or a combination of these types.
3. Materials, work-in-process, finished-product, or final inspection, and functional inspection.
4. Visual and nonvisual inspection, such as inspection of chemical composition, tensile strength, ductility.

Remedial and preventive inspection. *Remedial inspection* strives to detect defects that have already occurred, thus safeguarding the good name of the manufacturer as well as protecting the consumer, and to eliminate further waste by expending additional work on a defective part or product. Remedial inspection or *corrective inspection* strives to filter the good from the bad. *Preventive inspection* gives special attention to the accuracy of manufacturing processes in order to avoid defects and waste. Preventive or *constructive inspection* emphasizes the positive attitude rather than the negative. Corrective inspection detects parts that are defective, and the worker is usually required to repair them on his own time or he is not paid for them if they must be scrapped, whereas preventive inspection often is used in connection with a special incentive for quality achievement. Preventive inspection does not necessarily have to be tied into any special wage scheme; neither does remedial inspection. The major difference between the two types of inspection is the emphasis of one upon detecting defects that have been produced, and of the other upon preventing their occurrence.

Centralized inspection. Centralized inspection gets its name from the fact that items are not inspected at the work place but are brought together in a central location for inspection. It does not necessarily follow that there will be only one place in a plant where inspection of this type is carried on. As a matter of fact, there may even be two or more places in one large department where parts are taken for inspection. Centralized inspection usually is performed in a place set aside for the purpose, often within an enclosure especially adapted or equipped. Centralized inspection carries the *principle of specialization* somewhat further than floor inspection. Under certain operating conditions and in the case of certain products centralized inspection has some outstanding advantages, such as the following:

1. The inspector's output should be greater because of better working surroundings, less interference, and increased speed arising from specialization.
2. It is easier to supervise the inspectors; their tasks may be subdivided, and a less skilled type of worker may be used.
3. There should be less interference with the workers in production and better shop housekeeping when the products are not held at the work place for inspection.
4. Centralized inspection produces more impartial inspection; at least the inspector is not under the strain of rejecting the work of a man with whom he is in personal contact.
5. Centralized inspection facilitates the use of specialized and delicate equipment, such as the X-rays, radio amplification, and special lights.
6. Records of approved and rejected parts, together with the source of each, are more readily kept under centralized inspection.
7. Production control is facilitated when parts pass through a central location, where a total count of approvals and rejections is made.

Although centralized inspection has advantages for certain situations, it has also some inherent disadvantages, and in some situations, such as the manufacture of heavy parts or products, it may be highly impracticable. Centralized inspection tends to increase the need to transport material, except when the inspection is performed in the stores department or the finished stockroom when these are used. There also is likely to be an increased inventory of work in process unless the centralized inspection is performed in the stores department or stockroom. It is also apparent that centralized inspection is not feasible in progressive manufacturing, at least for the parts, although the final product may be so inspected.

Floor inspection. Floor inspection is inspection of the part or product at or adjacent to its place of production. If the volume of production justifies an inspector's remaining in one place, as on an assembly line or in a given work center, the inspection is relatively stationary as far as location is concerned. Not infrequently, however, an inspector may be

what is known as a "roaming inspector" and cover a large area. The nature of the product, the type of processing, and the inspection itself control the movements of the inspector when inspection is performed on the production floor.

Materials, work-in-process, finished-product, and functional inspection. This type is often subdivided into inspection of purchased or raw materials and manufacturing inspection. The essential characteristics of inspecting work in process have been covered under the discussion of centralized and floor inspection. A few other observations in connection with *manufacturing inspection,* however, may be in order.

Inspection problems in assembly industries are somewhat different from inspection problems in continuous industries. In continuous industries the general problem of manufacturing inspection is to develop good quality in the final product. Frequently the purpose of the inspection work is to rate the product for quality after it is produced. In continuous industries, such as the manufacture of paper, textiles, or chemicals, a defect in manufacture is likely to make the material a "second," and there is frequently no possibility of correcting the defect. Thus the operation of an inspection department in such industries includes preventing defects wherever possible, noting defects after they have occurred, and deciding whether such defects may be remedied or whether the goods must be placed in a lower classification of products or scrapped.

In assembly industries inspection includes attention to accuracy of manufacture and to interchangeability. The American system of manufacture has been established on the basis of interchangeable parts. From a production-control standpoint, as well as from the standpoint of the assembly operations, this interchangeability of parts in assembled products is essential in order that specific parts, when started in manufacture, need not be designated for specific pieces of final product. Inspection of components during the manufacturing process affords the inspection department an especially good opportunity to practice "preventive medicine" in assembly industries.

One phase of inspection of the finished product remains to be examined, namely, the *engineering inspection.* Certain types of products, such as large machinery units, are completely fabricated on the assembly or erection floor and accurately tested by technical experts to determine their operating characteristics. Large motors, turbines, generators, and similar products are thus tested by the Allis-Chalmers Corporation. In some instances representatives of the purchaser, particularly in governmental purchases, are present at these inspections. Airplanes are usually flight-tested, and steamships given trial runs.

Functional inspection of parts usually consists of placing the part in a skeletonized assembly and operating it to see if it performs the desired function.

Visual inspection merely refers to the method of inspecting. The name is self-explanatory. This type of inspection has been sufficiently covered in discussions of the other three classifications.

Location of the inspection department in the organization. As was pointed out in Chapter 6, an inspection department should never be made directly subservient to the will of those engaged in increasing the quantity of production. Unless quality of work is of very small significance in the successful operation of a plant, such a scheme for the location of inspection work should be avoided.

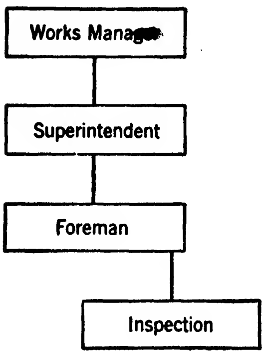


FIG. 11.2. Poor location of an inspection department when quality is of any major importance.

If the foreman has charge of inspection work, manifestly he cannot be expected to be rigorous in his application of manufacturing standards and, at the same time, force quantity production through his department (Fig. 11.2). This does not imply that the foreman should not be interested in quality; quite the contrary, for the foreman is responsible for the creation of a quality product.

If quality is not of extreme importance in an industry, inspection forces may be maintained as a staff department under the superintendent, as illustrated in Fig. 11.3. This arrangement places the foreman in a position of receiving instructions regarding the amount and quality of the product to be produced from two sources. He must endeavor to correlate his instructions, and, if these instructions conflict, the matter will naturally be referred to the superintendent for decision.

If quality is of maximum importance, as in the production of scientific instruments or in goods sold mainly on the basis of quality rather than the basis of price, the inspection department should be a major manufacturing function directly under the control of the works manager (Fig. 11.4). The inspection function will thus hold a position analogous to that of the purchasing department or the engineering department on the illustrative organization chart (Fig. 6.5).

Figure 11.5 shows the quality-control system of a large electrical manufacturing enterprise. It illustrates how intimately engineering, purchasing, and operations are tied together to establish and maintain tech-

nical standards. This chart also shows the progressive inspection from raw materials to finished product.

Figure 11.6 shows the quality-control system of a large steel mill. This system also exemplifies the closed inspection cycle with the consumer as the end man, both sending and receiving.

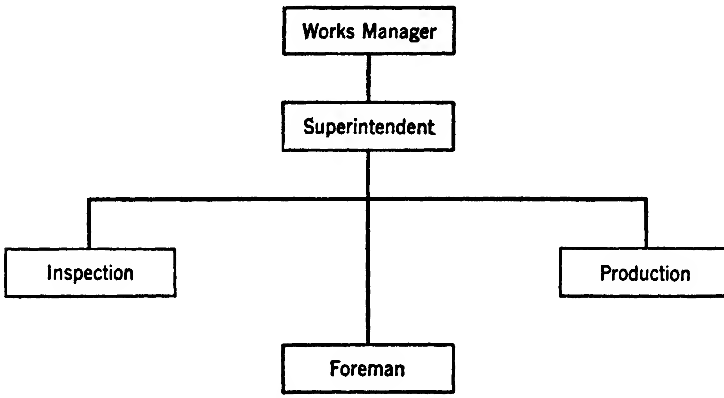


FIG. 11.3. Location of the inspection department when quality is not of extreme importance.

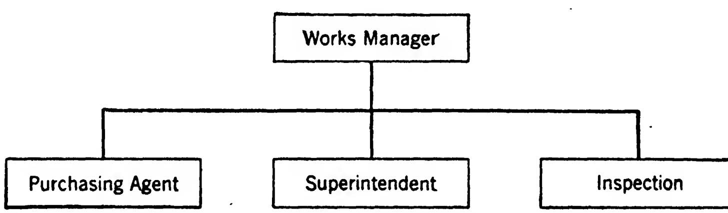
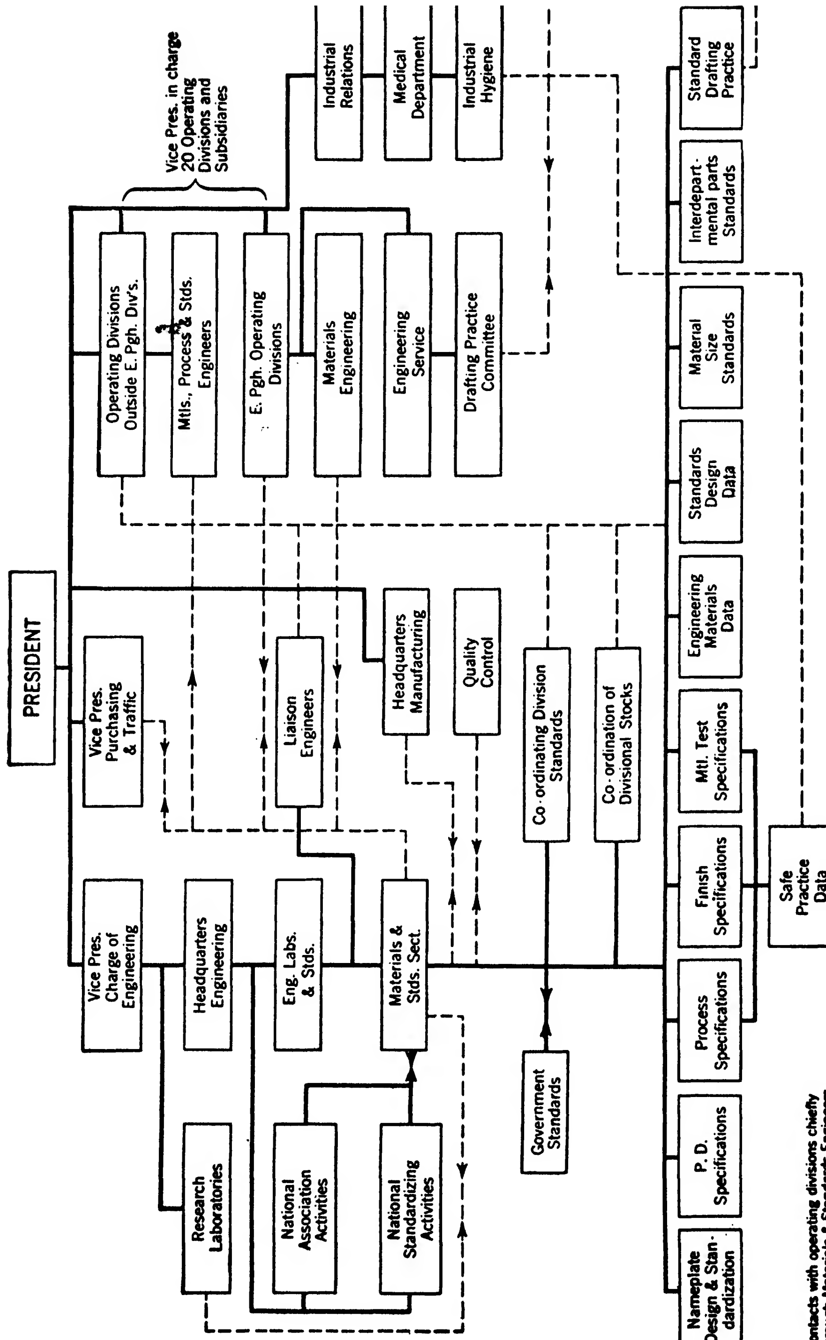


FIG. 11.4. Location of the inspection department when inspection is of maximum importance.

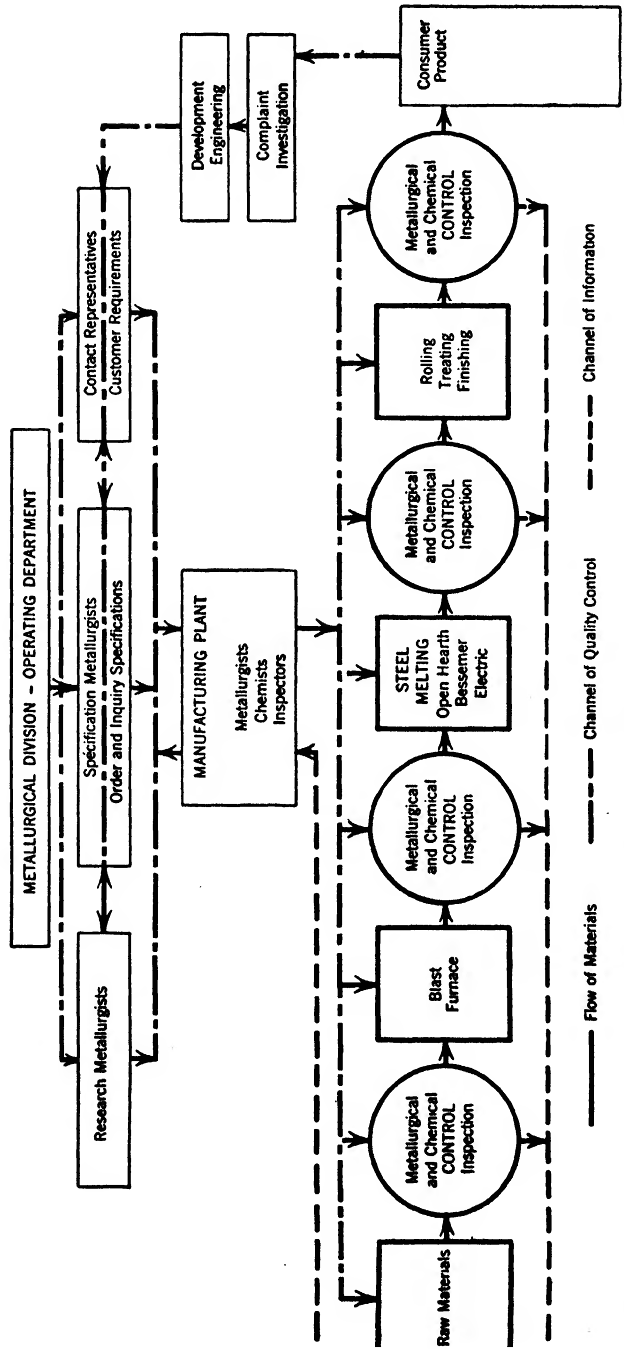
The inspection department's operations. Sometimes the inspector, at the request of the foreman, may instruct the worker in ways to overcome defects. In such instances preventive inspection is being practiced. The inspection department is an effective aid to the foreman, the planning department, the training department, or the methods department, whichever of these directs the methods of operation and the instruction of the worker.

The inspection department should have full control over both inspection of purchased materials and parts and inspection incident to production. The first control enables the department to maintain the material standards which have been set, and the second makes it possible to maintain



Courtesy, Westinghouse Electric and Manufacturing Compa

Fig. 11.5. Standardization system of a large manufacturing company.



IG. 11.6. Chart of the quality control in the Carnegie-Illinois Steel Corporation, compiled from data presented in an address by Mr. Richard W. Simon before the American Management Association. (See *A.M.A. Production Series*, No. 114.)

product standards. Frequently the work of inspection incident to production will closely approximate the type of inspection on purchased materials. An instance is the case of a part to be made from soft steel for economical working and then to be hardened and tempered to fit it for the service requirements of the finished product. This illustration should indicate the necessity of an inspection department's having full control of all inspection operations.

When to inspect. The four major problems facing those who are developing the operating methods of an inspection department are when, where, how much, and how to inspect. A decision concerning when to inspect cannot be made without considering the importance of quality in the product and the possibilities of reworking the product after the various operations. It is easy to set up so many quality checks that the responsibility for quality is actually shifted from the shoulders of the workers and foremen to those of the inspection department. This is psychologically wrong, as, even in those industries which have the fewest quality demands, the workers should be held responsible for quality within the set limits.

In machining operations of an automatic or semiautomatic nature, parts should be carefully inspected after each new setup until they meet specifications. They may then be inspected at infrequent intervals just to make certain that there has been no change in the setup and that no serious variation is arising from wear of the cutting tools.

As a minimum control, the final product should be inspected before it is shipped to the consumer or sent to stock. In certain cases inspection should be made after each operation. Between these two extremes lies the usual situation. In some industries inspection is so important for the ensuing operations and for the maintenance of product standards that it must be regarded as a process in the manufacturing cycle just before assembly operations. Usually a series of operations can be grouped, and the product inspected after the last of this group of operations. After any operation in which the worker is not able to measure quality exactly, however, inspection must be made.

Quantity to inspect. In high-quality products or those manufactured largely through skill of the worker rather than skill of the machine, much more of the product must be inspected than is necessary when the machine, once set up, is likely to turn out standard-quality products for a considerable time without adjustment. In the latter situation, inspection must be made frequently enough to ascertain that the equipment is operating satisfactorily and does not need adjustment other than the usual adjustment made by the worker on the job. In the former situation, frequently 100 per cent inspection will be necessary; that is, every unit of

product must be inspected after every operation. The more automatic the machine, the less attention need be given to inspecting the product after the initial inspection of the setup.

Inspection by sampling. Sampling is a means of greatly reducing inspection costs, provided that proper checks are instituted. While in production, the article may be inspected by checking some of the pieces that the worker has just finished, or the product may be inspected in an inspection department after the operation has been completed on a given lot. On continuous processes, such as those in which process conveyors are used, check inspection is made by a walking inspector who may come to any point of the line at any time and check a unit of product at any point of completion. One method of checking sample inspection is to reinspect lots which have already been inspected; another is to have an inspector check through a lot which he has already handled, after the lot number has been changed so that it will not be recognizable.

Theoretically, sampling as a method of inspection should not be used until the production processes have been standardized and brought under control through the elimination of assignable causes of quality variation. Investigations have shown that statistical methods provide the best means of detecting these assignable causes and make it possible to establish limits within which variations in any quality of interest to management should be left to chance.[1] After the elimination of the assignable causes of defects, quality tends to remain within limits of variation attributable to chance. Further studies have led to the conclusion that, once this point of control has been reached, there usually is no practical advantage in further inspection to eliminate chance variations.[2] Under these conditions detailed inspection may logically be replaced by sampling inspection with considerable savings in inspection costs.[3]

The adoption of an inspection plan by sampling is based on the premise that a *certain percentage of the output will not conform to the standard specifications.* An allowable percentage of defective product in any lot inspected may be specified in determining between a satisfactory lot and a rejected lot. According to the laws of chance, a sample will occasionally give a *favorable indication for a bad lot,* resulting in the passing of this lot for use in further production or for delivery to the con-

[1] See "Applications of Statistical Method in Engineering and Manufacturing," *Mechanical Engineering,* November, 1932, p. 778.

[2] W. A. Shewhart, "Economic Quality Control of Manufactured Products," *Bell Telephone System Monograph, B496.*

[3] Frank J. Feely, "Quality Control in Manufacturing," *Mechanical Engineering,* October, 1935, p. 641.

sumer.[4] This is often called the "consumer's risk." In addition to the consumer's risk there is another variable, namely, a value for the *average percentage of defective product that will generally exist in any accepted lot over a long period of time.* This variable is known as the "average outgoing quality limit" and is defined numerically as the *probability of passing any lot submitted for inspection which contains the previously determined tolerance number of allowable defects.*

A third factor essential to the design of a workable sampling scheme for inspection is a knowledge of the average percentage of defective parts existing in the product submitted for inspection. This factor, known as the "incoming process average," is obtained from inspection records of previously inspected lots and is an estimate of the expected quality under normal conditions. (See Fig. 11.7 for an inspection form from which this information is collected.) The extent of fluctuation from the incoming process average indicates the control or lack of control during processing and is of vital importance in considering the size of the sample required.[5]

It should be acknowledged here that in actual practice much of the inspection by sampling is not based upon scientific use of statistical processes but rather upon empirical judgment. This accounts in part for some of the turmoil in which inspection departments and producing units frequently find themselves.

The number of inspectors needed. It is obvious that a continuous-process industry producing a single product will require less inspection than a jobbing type of industry producing many types of quality products. Institutions producing a high-quality precision type of product also require more inspectors than the same general type of industry producing a lower-quality product. Again, if a special-purpose machine is used where volume justifies, the product requires less inspection than the same item manufacured by general-purpose machines. It is true that the special-purpose machine itself may require more checking and maintenance than the general-purpose machine, but the maintenance group is not usually classified with the inspectors. The organizational setup may also influence the number of inspectors required. Where the direct supervisory force is adequate to keep a close check on the quality of production, the amount of inspection necessary to measure quality is reduced. Modern precision equipment and techniques have greatly reduced the number of inspectors required to maintain the quality desired.

[4] H. F. Dodge and H. G. Romig, "A Method of Sampling Inspection," *The Bell System Technical Journal,* October, 1929, p. 628.

[5] See John D. Golder, *Quality Control in Selected Industries,* p. 70 (unpublished thesis, Northwestern University, 1939).

Assembly-line inspection. An inspector may be stationed at the end of the assembly line not only to inspect but also to count the number of good pieces for which credit will be given. If any parts are thrown out

INSPECTOR'S DAILY REPORT

Job No.	Shop Order Number	Piece Part Number	Total Lot Amount	Time Start-ed	Time Worked	Sample Inspection				Detail Inspection		Rate per Hr.	
						First Sample		Total Sample					
						Total	Def.	Total	Def.	Total	Def.		
1													
2													
3													
4													
5													
6													
7													
23													
24													
25													
Clock No.		Name			Dep't				Date				

(Front)

DEFECT SUMMARY																			
Job No.	Type of Defect																		
	Piece Part Number																		
1																			
2																			
3																			
4																			
5																			
6																			
25																			
	Totals																		

(Reverse)

Fig. 11.7. Inspector's daily report.

for defects, it is the practice to require the line to make the repairs without extra compensation. This arrangement encourages worker inspection as the processes are carried on. On an intricate assembly line, such as a motor assembly, however, there must be floating inspectors who inspect periodically at the end of one or more of a group of operations.

Inspection techniques. The operation of the inspection department is facilitated through the development of inspection standards which are known to all concerned. These standards should be in writing if possible and should indicate the most frequent causes of defects in manufacturing. The standards should be specific in listing requirements, but these requirements should be reasonable in order to secure the cooperation of the production organization.

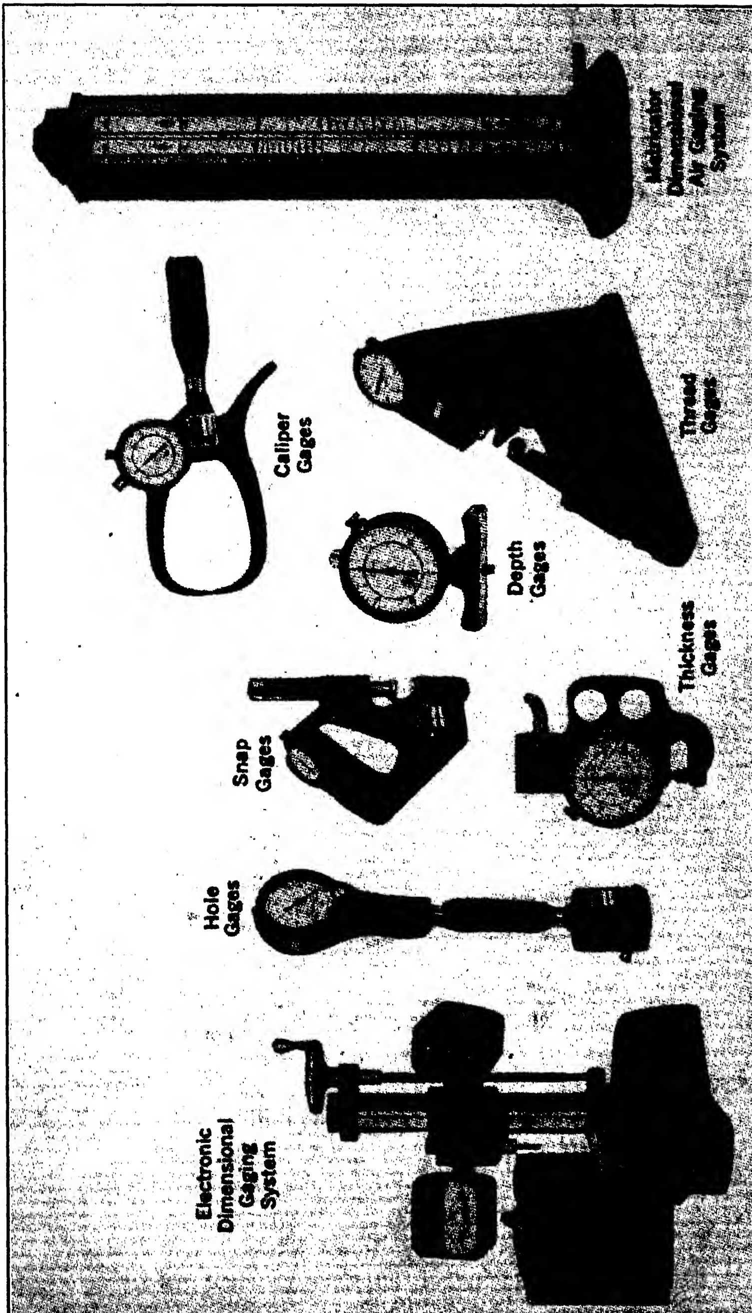
Manufacturing tolerances should be set up with great care in order that unnecessarily high precision and attendant high manufacturing costs will not be required. Carefully established tolerances will prevent the waste of unnecessarily high precision. The tolerances should not be regarded as the dimension or quality to aim at. Many manufacturers have frequently made the mistake of working to limits, with large rejections as the result; in other words, they have aimed at the outer circle of the target, rather than at the bull's-eye. Rejects of valuable parts should be reinspected, perhaps by line-production men, to determine if it is worth while to try to save the units by a special manufacturing process.

On machined parts "go and no-go" gauges that are set at the proper limits provide a quick way of checking the parts without gauge adjustment. Many devices can be set up in the inspection cage or on the inspection bench which will determine positively whether a part is good or bad without elaborate adjustments. (See Fig. 11.8 for a variety of gauges used in industry.)

An inspection department may be organized by having in charge of each operation, department, or unit of product highly qualified inspectors who are responsible for that portion of the work and who report to a chief inspector only on matters of broad inspection policy. Instead, the department may be organized so that a large number of inspectors with meager authority do the physical work of inspection, call the attention of chief inspectors to defects, or have their work checked by chief inspectors. This system is particularly applicable in large companies which must have inspection departments with a rather large personnel.

Mechanical aids used in inspecting. Figure 11.9 illustrates a special inspection device for inspecting a mass-production part. This particular equipment gives ten dial readings at one time. Similar mass-production-inspecting equipment may be constructed for almost any part where the volume justifies the cost involved. Inspection aids vary in complexity from the simple plug gauge all the way to the complicated machine for inspecting camshafts (Fig. 11.10) and the X-ray machine.

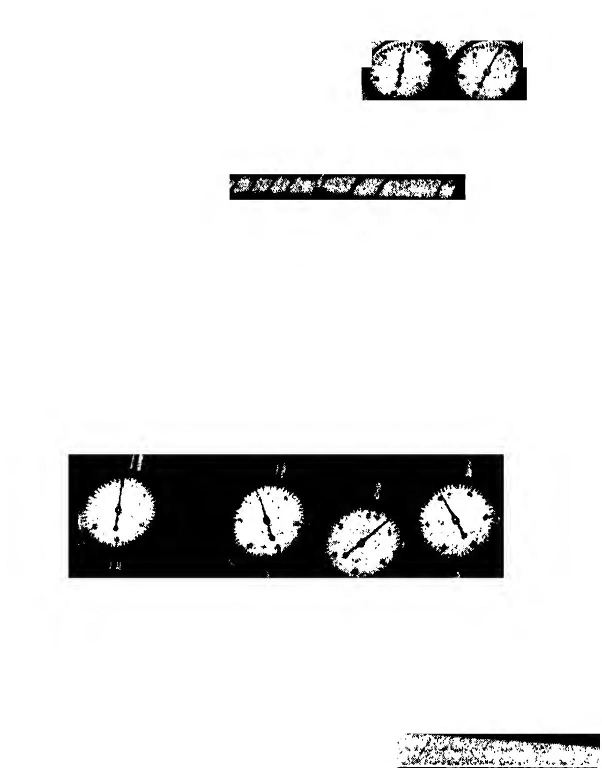
The different types of inspection equipment may for convenience be divided into five groups, namely, production gauges, automatic testing equipment, the X-ray, electrical devices, and laboratory equipment.



Courtesy, Federal Products Corporation

FIG. 11.8. A variety of gauges used in inspection.

1. Gauges. The manufacture of interchangeable parts requires precise duplication of these parts within established tolerances. By far the most common form of device used in measuring conformity to standards is the gauge. In the metal trades in addition to the micrometer, familiar to students of high school physics, gauges may be classified according to



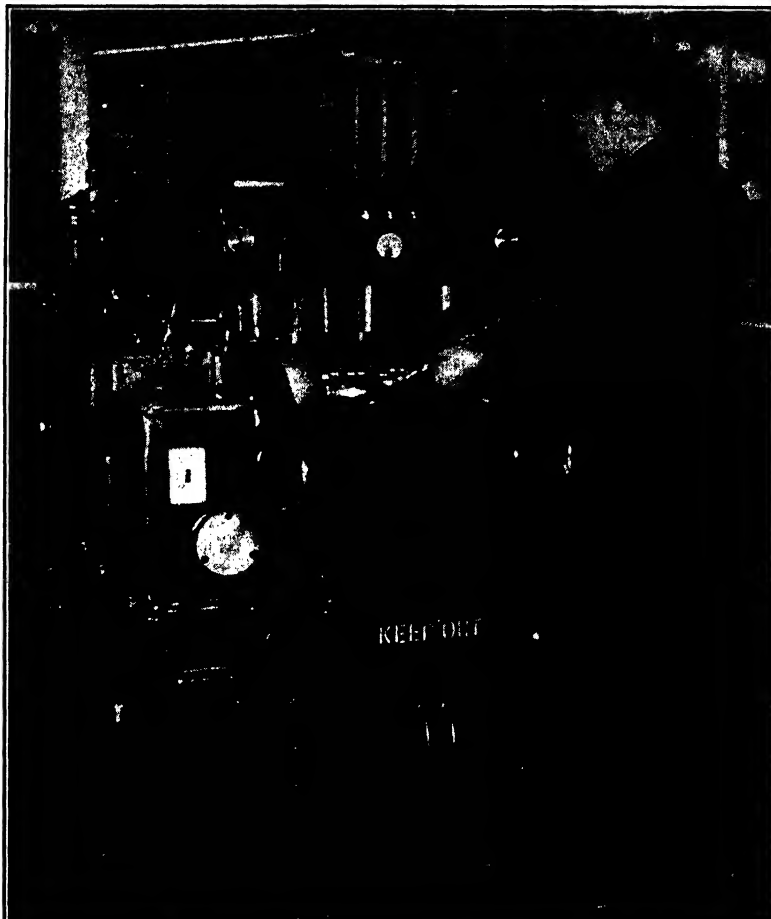
Courtesy, Federal Products Corporation

FIG. 11.9. Mass-production diameter gauge.

their purpose: working gauges, inspection gauges, and master gauges. Working gauges used by the workmen in performing the operations are limit gauges for checking each step as it is performed. Inspection gauges are used by process inspectors to check the product before its final assembly with other parts or before sending it to stock.

Plug gauges are among the oldest and simplest tools used in inspection. They consist of pieces of metal turned to the maximum and minimum dimensions. It is customary to incorporate these two dimensions into one gauge to facilitate rapid inspection, thus producing a two-step plug gauge. Inspection consists of inserting the gauge in the hole and observ-

ing the fit. Profile or contour gauges perform a function similar to that of the plug gauge but measure contours. Figure 11.11 illustrates a contour gauge for checking the cross-sectional area and contour of a railroad



Courtesy, "Steel"

FIG. 11.10. Electrically operated automobile camshaft tester at Ford Motor Company Rouge Plant, Dearborn, Mich.

rail. Figure 11.12 illustrates the multiplying lever indicating gauge, the principle of which has been adapted for many types of operations and processes, from checking the thickness of a given part already processed to checking the product during continuous operations, such as gauging the thickness of fabric as it is being rubberized while going through a calendar. Master gauges are the gauges which are used for checking

working and inspection gauges. These gauges are accurate to a very high degree and usually consist of discs or blocks ground to exact dimensions. They are used to check the operating gauges by having the production gauge check the dimensions of the known master.

2. Automatic testing equipment. Automatic testing equipment has made remarkable progress since the introduction of the photoelectric cell. Some applications of its use to industrial inspection are as follows: detection of fine cracks in polished surfaces, inspection of storage battery caps for vent holes, control of enamel thicknesses on wire, rejection of dull

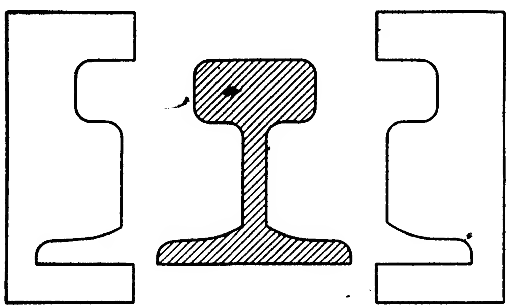


FIG. 11.11. A simple contour or profile gauge.

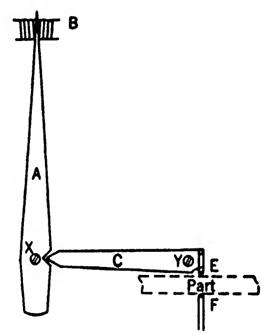


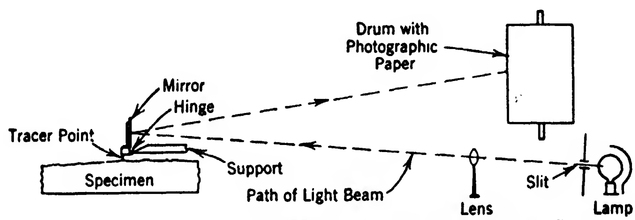
FIG. 11.12. Multiplying lever indicating gauge.

razor blades, color measurements, and the calipering of steel balls. Other uses of this mechanism include the grading of cigars and tile, the detection of missing labels on canned goods, the inspection of tin plate, and the matching of false teeth.

The electrically operated camshaft tester (Fig. 11.10) used by the Ford Motor Company at its Rouge Plant is an excellent example of mechanical inspection. Twenty-five different measurements must be checked by this machine. If any of these measurements made by the machine exceed the plus or minus tolerances of 0.00025 inch in some places and 0.0001 inch in others, the spot is marked, and the shaft is discharged through a chute so that it is separate from the approved camshafts.

Another illustration of the application of scientific knowledge and mechanical ingenuity is the device used by the Timken Roller Bearing Company of Canton, Ohio. Figure 11.13 graphically portrays the Timken Profilograph. This Profilograph, using a ray of light, can accurately measure in terms of a millionth of an inch (0.000001 inch) variations in surface finish.

3. The X-ray. The X-ray machine is usually associated with the medical or dental profession or the research laboratory. In recent years, however, its practical manufacturing use has been demonstrated in detecting flaws in materials not discernible by ordinary visual or gauging techniques. Its most extensive use at present is in connection with the examination of steel and iron castings and rolled steel sections for internal flaws. Such defects can be detected before expensive operations are performed on these parts.



Courtesy, Timken Roller Bearing Company

FIG. 11.13. Profilograph for measuring the smoothness of the mirrorlike surface of a bearing. (A ray of light from a fixed source is directed through a tiny slot and focused on the mirror by means of a special lens. This ray is reflected by the mirror and strikes a sensitized sheet of photographic paper mounted on a revolving drum, thus automatically making a permanent record. As the diamond point moves up and down on its hinge, following the variations in surface finish on the specimen being examined, the mirror tilts and the ray of light moves up and down over the sensitized paper, leaving a record on the photographic paper.)

4. Electrical devices. Electrical test sets are used extensively in the electrical and automotive industries. Their prime purpose is to test the electrical characteristics of a component part or to check the proper action of the final assembly. In the electrical industry, for example, they are used to check the proper winding of armatures and field cores. The stroboscope is a device which enables an inspector to study the action of an object moving at high speed to determine any irregularities due to vibrations, eccentricities, or defective parts. By its use a given tooth of a saw revolving at 7200 cycles per minute can be studied as if it were standing still.

5. Laboratory equipment. Almost every type of laboratory equipment is used somewhere in industry for inspection purposes. Chemical analyses of almost every description are used in some process controls, as also are tests for physical characteristics, such as hardness and tensile strength. The steel industry makes use of both types of tests. The rubber industry, particularly in its compounding and curing operations, makes extensive chemical tests.

PART IV

THE PLANT AND EQUIPMENT

CHAPTER 12

THE FACTORY BUILDING AND PLANT LAYOUT

Plant Layout

The general approach. Plant layout is vital both in processing and in effective storage of materials. An enterprise constructing a new building may well provide an ideal layout for the manufacturing process, with due regard for flexibility, and then erect the building around this layout. The nature of the terrain and the available land area may make it impossible to build the factory in keeping with this ideal layout. Nevertheless, the essential features of the desired layout nearly always may be secured by making the building higher, if ground space does not make possible the long straight-line conveyors sought. It is true that a multiple-story building is more expensive, but this factor is not controlling, so far as an efficient layout is concerned, provided that the same plot of ground is to be used anyway. The plant is primarily constructed for the purposes of housing manufacturing processes and of protecting materials and the finished product from the ravages of the elements.

The size of the department. A few companies have adopted the small-department idea as the basis of their layout. A limit is set, beyond which a given department is not allowed to grow. When the work of a department grows beyond the limit set, another department is created under the same roof to do the same work but under different supervisors. The layout in many new buildings provides for such division in the first instance. This plan promotes more adequate supervision. One foreman or superintendent cannot carry in mind the details of operation of more than a certain number of machines, a certain number of operators, or a certain number of units of product. Regardless of how much he may delegate his responsibility, he may have more work (although not necessarily more functions) than he can handle. To avoid this complication similar operations may be split into several departments under the control of different foremen, whose relationship to the remainder of the

factory organization is exactly the same as if the work were being carried on in one department. The element of competition between like departments is a valuable feature of this plan. Some companies separate all overhead by competing sections, even installing separate electric meters to measure the power used by the several departments.

Factors that influence the plant layout. The type of industry, the quantity of production, the type of product, the type of operations, and the type of worker must be considered in determining the final plant layout. The industry may be either a continuous or an assembly type. A *continuous industry* is one in which all the material is received at one point, from which successive operations turn it into a finished product, as in yarn spinning and paper and pottery manufacture. An *assembly industry* is one in which the finished product can be produced only after various components have been made and then brought together for final operations, such as the manufacture of shoes, clothing, and automobiles. In factory layout this difference is significant. Some continuous industries are *synthetic;* that is, the product is obtained by bringing together various ingredients which are combined in the manufacturing process, as paper manufacture or yarn spinning. Other continuous industries are *analytical;* that is, the product is obtained by successive processes that separate the final product from the mass of original material. All refining industries, such as oil and by-products of coke, are of this nature.

Assembly industries are also of two types: (1) those in which the *components are similar* and go through similar operations, as, for instance, the clothing industry; and (2) those in which the *components are dissimilar* and go through unlike processes, as, for instance, the automobile industry.

The type of worker is a fundamental consideration, particularly in the employment of women workers, where many decisions concerning factory layout must be changed because of the requirements of these employees.

The type of product, that is, whether the product is heavy or light, large or small, liquid or solid, is another fundamental consideration in plant layout. Although the manufacture of spark plugs and locomotives both involve assembly work, layout problems differ materially. Layout problems in any plant in which the product can be flowed, either by gravity or by pumps, from one operation to another, as in flour or sugar manufacture, differ from those in which work in process must be handled by hand, conveyor, or truck in moving from one operation to the next.

Certain types of operations make it imperative that they be considered first in making layout plans. Such are wet operations, as leather tanning or textile dyeing; operations involving heavy machinery, as large hy-

draulic presses; and operations which involve fire risk, as the manufacture of powder or linoleum.

One other factor markedly influences plant layout, namely, the type of manufacture—whether repetitive operations on standardized products, usually involving mass production, are involved, or whether many unlike operations on nonstandard products, frequently referred to as *job-lot manufacturing*, is required. The industry that manufactures in large quantities a relatively few standardized products may be laid out on the so-called *straight-line* or *product* basis as well as the *functional* or *process* basis, whereas the job-lot type of industry is almost of necessity largely on the *functional* basis.

Balance in departments and operations. Balance provides for the elimination of limiting or bottle-neck operations, at the same time avoiding excess equipment for any operation. This is of particular importance in continuous-production plants. It is essential that the capacity of each department or of each machine working on each operation be sufficient properly to absorb the production of prior operations and to transmit to following operations sufficient product to keep the equipment fully utilized. Any other plan involves increasing inventories of material in process; overtime work, with its attendant increased costs; and general confusion, including utilization of expensive factory floor space for material tied up while in process.

There is no formula for determining the proper balance in equipment, especially in job-lot manufacturing. Experience and careful analysis of previous performance are the best guides. A change in process or design may destroy an ideal balance. Balance is a goal toward which management is ever striving, but which requires constant vigilance to approximate and retain.

Production centers. Production centers should be provided within the departments. Instead of the worker and his machine being considered the unit for which space must be provided, each worker tending a group of machines or each machine tended by a group of workers should be looked upon as a production center. The production center includes the workmen, the machines, space for storage of raw material and completed units from the operation, supplementary apparatus of any kind needed in the performance of the operation, and a share of the aisle space required between this production center and the next (Fig. 12.1). The importance of the machine as the basis of production in modern industry frequently makes a factory floor a succession of similar production centers.

Layout by product, or line layout. Layout by product implies that operations are performed in a sequence and that the product is assembled or worked upon as needed (Fig. 12.2). A theoretically perfect layout by

product would be one in which all parts, subassemblies, etc., would be started at just the right time to be ready when needed and would keep moving until the final product would be removed from the end of the assembly line. It is self-evident that no such processing would be practical save in a very simple product. Direct-line or straight-line layout, as it is sometimes called, is almost never found in industry in its pure state; however, it is the most popular type of layout in mass production.

Courtesy, International Detrola Corporation, Detroit

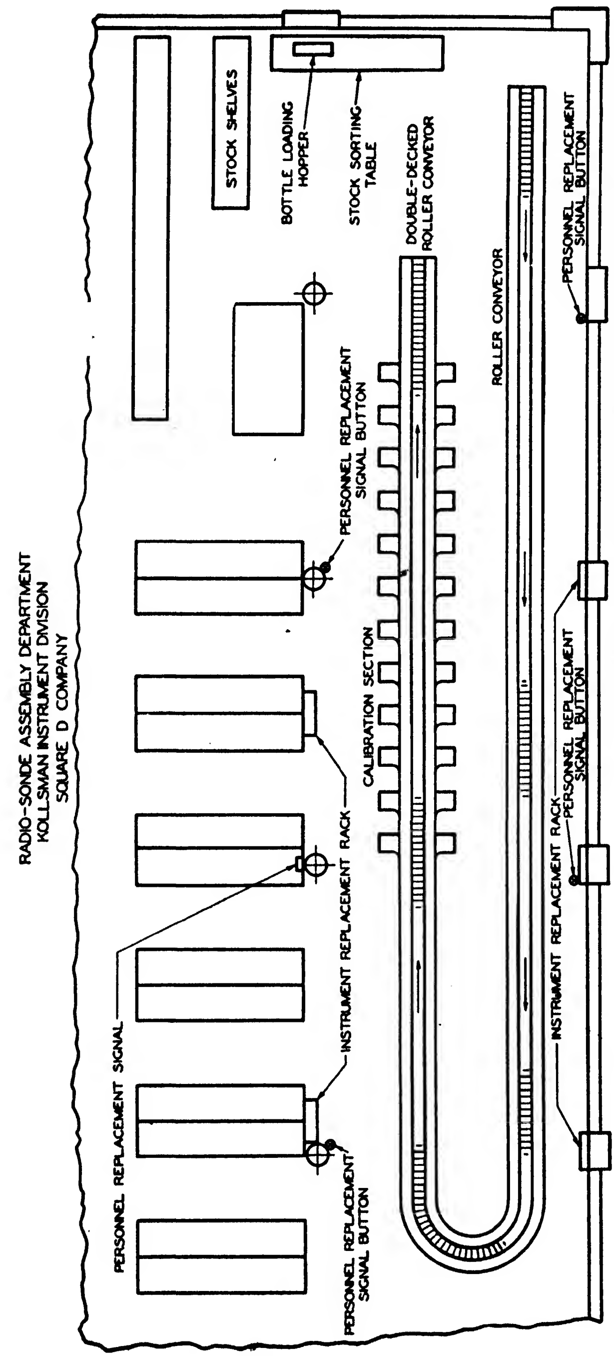
Fig. 12.1. Production center.

The ideal of straight-line layout can be attained most nearly in quantity-production plants producing standard products, but even then it is complicated by the following factors, which are always present in plants producing diversified products:

1. The necessity of placing all operations in the production line on the basis of certain considerations, such as the type of product or operation. Thus, many operations must have special light, such as cloth examining in clothing plants or wool sorting in woolen yarn plants, where the light should come from the north. Tanning vats in tanneries should be placed on solid ground because of their weight and the wetness of the operation.

2. The performance of two or more operations by the same worker, as in felling operations in the clothing industry. If each part moves quickly and is easy to handle, it may prove cheaper to move the material than to move the worker.

3. The use of the same machine on more than one operation in the process. It may be inadvisable to provide two machines, particularly if one operation will not keep one machine continuously employed.



Courtesy, Kollsman Instrument Division, Square D Company, Elmhurst, N. Y.

Fig. 12.2. A roller conveyor for assembling instruments.

Because of special conditions continuous compromise with the ideal is often necessary in striving for direct-line layout. Direct-line layout is applicable either to a single floor of the factory or to the building as a whole.

The central idea behind layout by product is a continuous flow of materials in process toward the finished-product stage. In summary, the advantages of layout by product[1] are as follows:

1. Facilitation of the use of material-handling devices and conservation of floor space.
2. Minimization of "back hauling" and internal transportation.
3. Tendency to eliminate bottle-necks when properly adjusted.
4. Shortening of the manufacturing time from the first operation to the finished product.
5. Facilitation of production control. When a product is once started along the line, it is difficult for it to be sidetracked.
6. Reduction of the work-in-process inventory.
7. Some reduction of the finished-product inventory, since production control is more complete and promises to customers from production are more reliable.

Some of the disadvantages of layout by product are:

1. Decreased flexibility. Changes in the product may require an entire rearrangement of the layout. Job lots are difficult, if not impossible, to handle.
2. Increased investment in equipment. A machine may be required to perform a certain operation in a given sequence, and the quantity of work to be done will not keep it busy.
3. Frequently greater difficulty in expanding production beyond the capacities of the lines in layout by product than in functional layout. Within the capacities of the lines in layout by product, however, considerable flexibility is achieved by adding or taking off workers and adjusting the conveyor speeds accordingly.
4. Greater difficulty in securing specialization in supervision.[2] There may be only one spot-welding operation on a line, while there is a great deal of electric welding somewhere else in the shop.

Layout by process. Layout by process or functional layout is characterized by the assembling of similar operations in one place; for instance, all drilling is performed in a drill-press department, and all electric welding is done in the electric-welding department. This type of layout carries out the functional idea of Frederick W. Taylor. It has much to commend it for job-lot manufacturing or the manufacture of non-

[1] Layout by product does not require straight-line processing, even though the term is often used. It merely implies continuous processing. Modern conveyors will turn corners and go from one floor to another.

[2] See Franklin E. Folts, *Introduction to Industrial Management*, McGraw-Hill Book Company, New York, 1938, pp. 245–265 for the case of Simonds Saw and Steel Company.

standardized products. The advantages claimed for layout by process are:

1. Greater flexibility, in that changes in operations and the sequence of operations seldom involve a change in layout.
2. Easier adjustment to changes in volume of production, especially when it is necessary to add equipment.
3. More ready adaptation to special needs arising from certain types of equipment, such as the protection of workers against exhausting fumes or the flashing of light in electric welding.
4. More complete utilization of equipment, and hence a lower investment in equipment.
5. Better utilization of the skill of the workers by following the principle of specialization.
6. More effective use of specialized abilities of supervisors.

The functional layout is strong where layout by product is weak, and weak where product layout is strong. It is seldom that an industrial enterprise of any magnitude is laid out solely on either a functional or a product basis. Many organizations, however, are predominately of one type or the other.

The disadvantages of functional layout are essentially the same as the advantages of the product type of layout:

1. Greater difficulty in automatic material handling and need for more floor space for the same volume of production.
2. Excessive back hauling of materials in process.
3. More time required to make the same product.
4. Greater difficulty in production control.
5. Excessive work-in-process inventory.
6. Tendency to increase the finished-stock inventory if the same service to customers is given as is accomplished under product layout.

Short moves. The transportation of material from one work center to another should involve as short a move as possible. Space should not be saved in a factory, however, at the expense of men or materials. Such economy results in a subsequent loss of production per worker far more costly than a comfortable layout would have been. Figure 12.3 shows the manner in which the Caterpillar Tractor Company stores materials immediately adjacent to the first operation. Machines are arrayed so that the finished product of one operation may be passed to the next operation with a minimum of handling.

If operations are so arranged in standard production that material can be handed or sent in chutes from one worker to another (see Fig. 12.4), the ideal of short moves is achieved. The same result is often accomplished when the worker receives his work from a moving conveyor and places it back on the same conveyor, from which the worker on the next

operation takes it (see Fig. 12.5). Workers on assembly lines can be placed as close together as material-storage conditions permit, but greater flexibility is achieved by having the original line provide for space between workers, which can be filled in later as operations change or production increases.

Courtesy, Detroit Steel Products Company

FIG. 12.3. Interior of plant of Caterpillar Tractor Company, Peoria, Ill. (Monitor roof over craneway for material handling, saw-tooth roof over manufacturing floor. Heavy material located immediately adjacent to first operation. Short moves and adequate material handling.)

Short moves increase in importance as a layout factor if the product is heavy and unwieldy. Conveying apparatus, however, has greatly decreased the cost of long moves and has in effect practically put machines or departments at a distance from each other in direct line.

Internal transportation. Adequate aisle space is the first and most important factor in adequate internal transportation. The aisles must be sufficient for all trucking requirements and must be kept clear, possibly by painting white or yellow lines upon the floor (see Fig. 12.6). Main aisles must be considered separately when space is calculated for production centers. Material handling is such an important phase of modern

industrial operations that this subject is treated more extensively in Chapter 13.

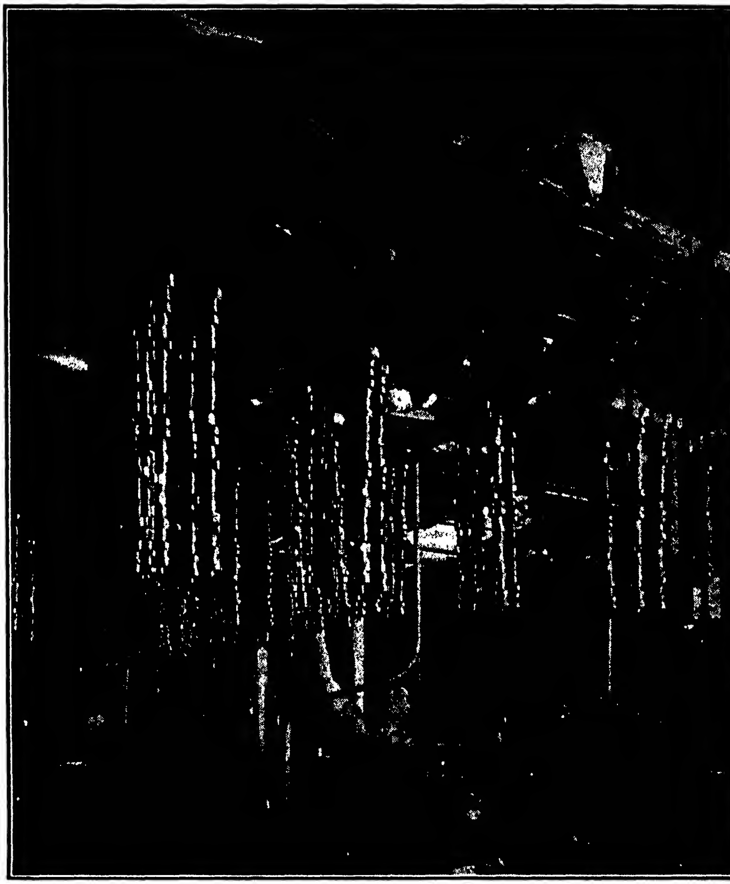
Service centers. Service centers include the toolrooms, storerooms, dressing rooms, restrooms, and lavatories that form a necessary part of

Courtesy, General Motors Corporation, Truck and Coach Division

Fig. 12.4. Connecting rods slide from one operator to another.

every plant. The shorter the distance from the operations to these centers, the less time will be consumed by workers going to and from their work places. It is advisable to have the restrooms separate from the locker and dressing rooms wherever possible, particularly for women workers. As a rule, the service centers should be in those parts of the premises where the light is least desirable. Frequently, it has been found possible to place the service centers on balconies between floors. This is naturally a big space-saver as well as a convenient arrangement as far as proximity to the processes is concerned. Another good arrangement for these centers is to place them in divisions of the process or in natural divisions between buildings or parts of the same building. In

this way these centers are brought into close proximity to the entrances, exits, and elevators (see Fig. 12.7).



Courtesy, "Automotive Industries"

FIG. 12.5. Moving partly machined camshafts by overhead conveyor at the Ford Motor Company Rouge Plant. (This company pioneered this method of handling materials between operations. When the worker needs a piece on which to perform his operation, he merely reaches up and takes one. When he is through with his operation, he places the piece once again on the conveyor line, which threads throughout the department.)

Some Illustrative Plant Layouts

The principles of plant layout may be more readily understood if a few typical examples are described.

Binder twine mill. The International Harvester Company's McCormick Twine Mill in Chicago has a plant layout which is an excellent

example of the straight-line or product type. It is essentially a pure type of layout by product, since the entire plant is devoted to the manufacture of one highly standardized product. The raw material is unloaded from the freight cars into the raw-material storage room, from which the material is drawn as needed for production. Figure 12.8 is a

Courtesy, "Automotive Industries"

FIG. 12.6. Mezzanines and final assembly, Chrysler Plant, Detroit. (Subassemblies on the mezzanine are carried by conveyor to the floor below. Note storage of material in trucks and tote boxes adjacent to the proper operation.)

simplified flow chart of the sequence of operations from the time the raw material is received until it is shipped. The plant has five stories in the manufacturing division. The first, second, fourth, and fifth floors are devoted to preparation and spinning, and the third floor is devoted exclusively to spinning. There is excellent balance in equipment, and the material moves as effectively as is possible in a five-floor building.

Wallpaper-printing layout, a problem in balance. Balance is sometimes difficult to obtain in continuous-line production. Figure 12.9 shows two arrangements for printing wallpaper. The top arrangement portrays the continuous flow of the raw material until it is wound up in small rolls ready to be bundled and shipped to the consumer. In order to make

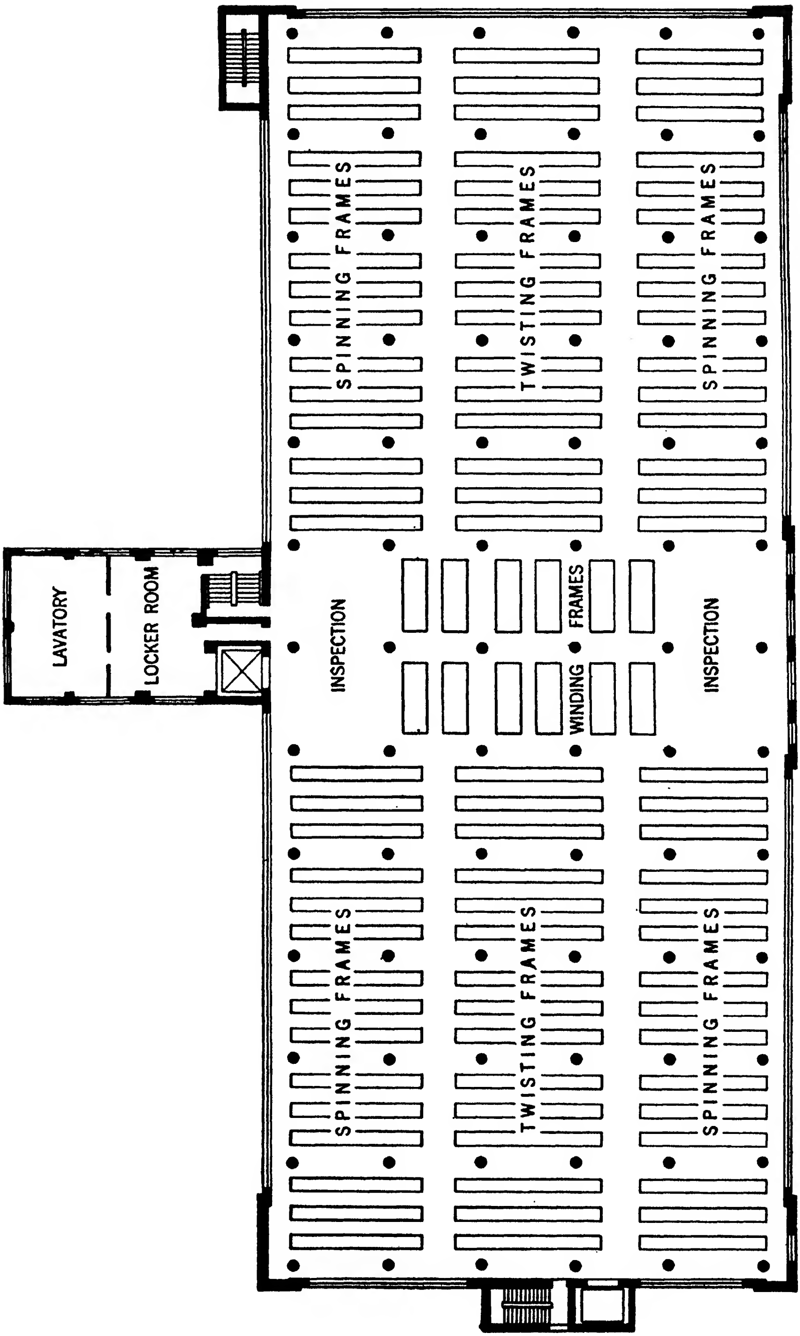
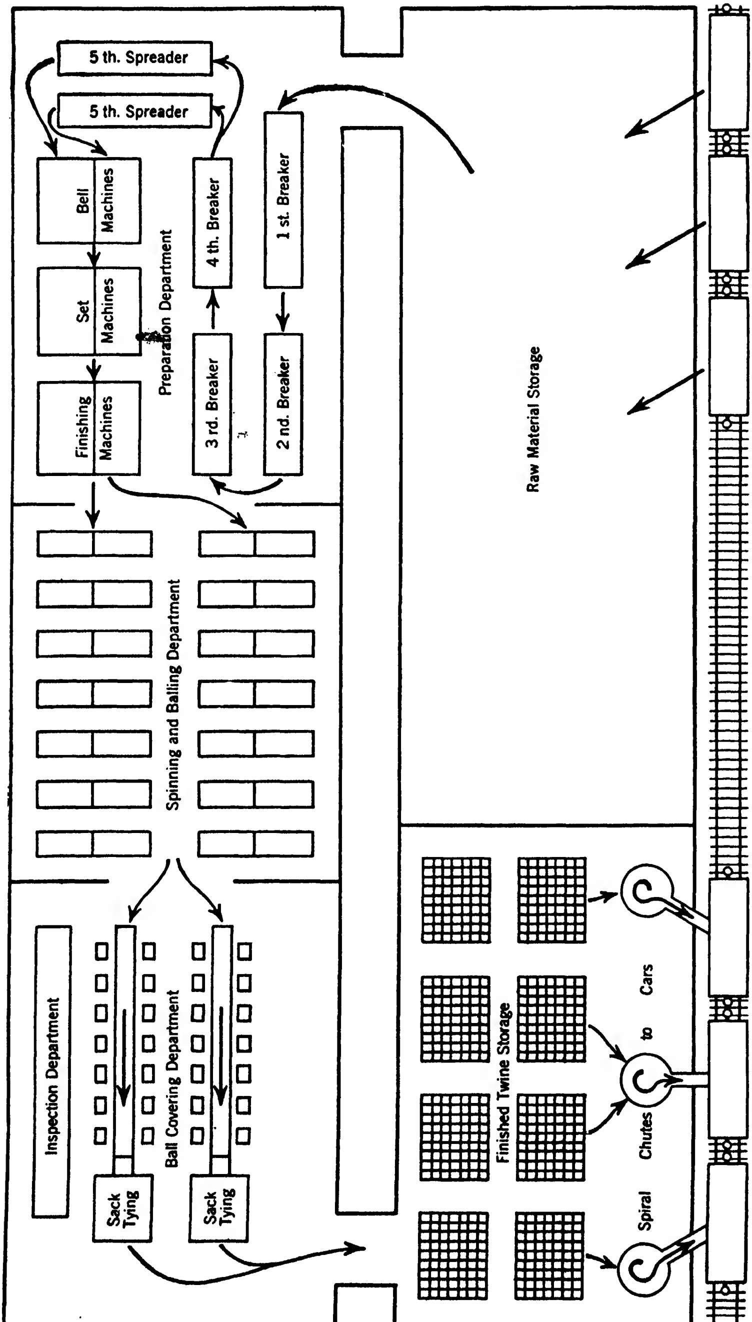


FIG. 12.7. Layout of spinning floors, Worsted-yarn Plant, James Lees & Sons Company.



Courtesy, International Harvester Company, Chicago

FIG. 12.8. Flow chart of McCormick Twine Mill, International Harvester Company, Chicago, Ill.

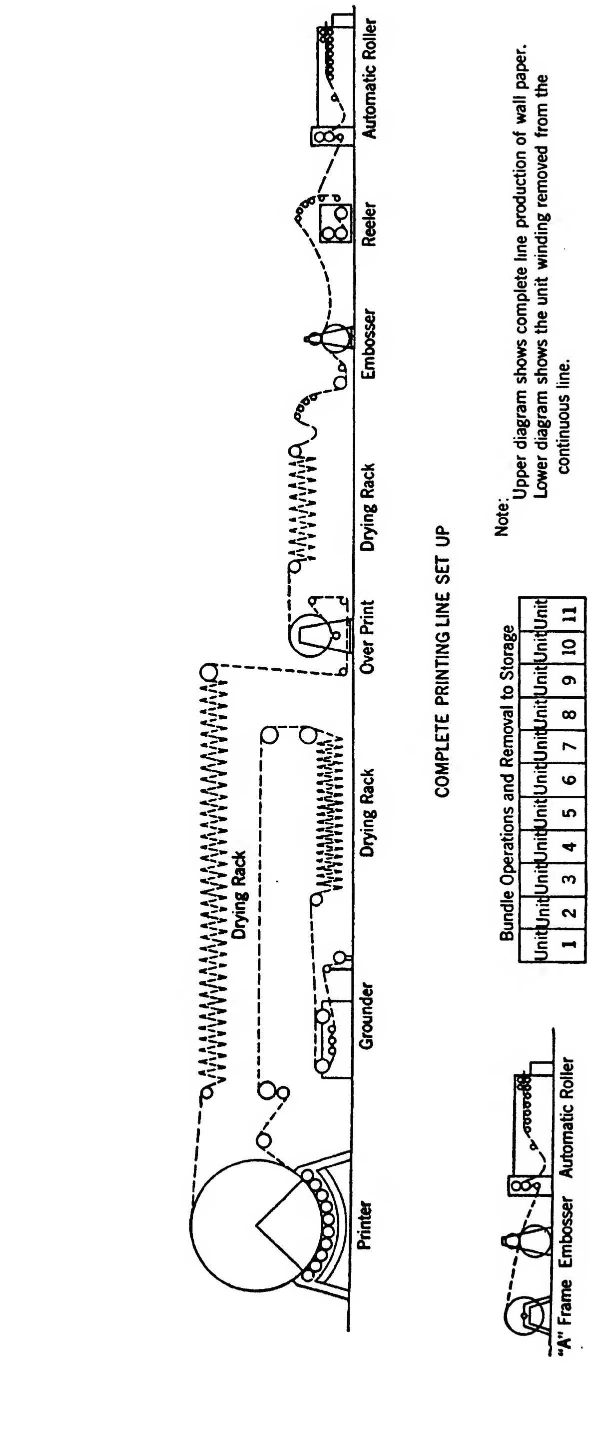


FIG. 12.9. Wallpaper-printing layout.

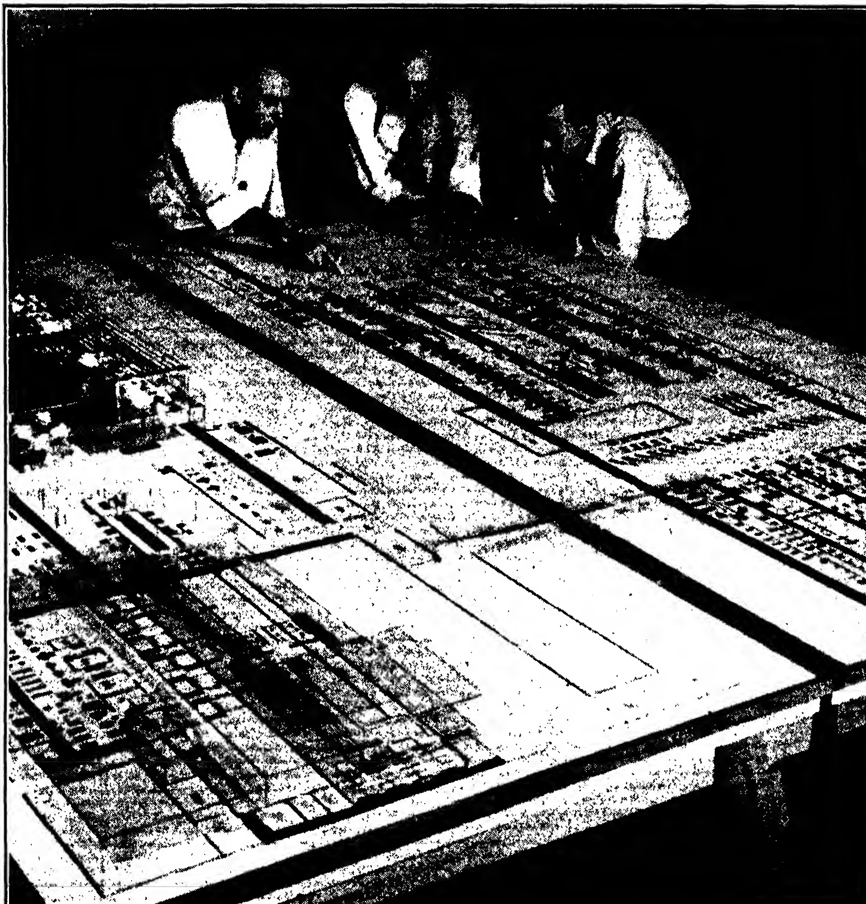
effective use of manpower in a multi-line plant the work of each man is arranged to cover the same operation on four lines of equipment. Since it takes several hours to change from one style to another, in practice the worker is attending only three machines at a time, the fourth one being down for a change-over. This arrangement of the men is satisfactory for all operations except the final one of tending the automatic roller, which requires the constant attention of one man. The automatic rolling machines can be operated at a higher speed than most of the others. It has therefore been found efficient, particularly when running the slow-speed (high-quality-production) setup, to remove the embossing and automatic rolling machine from the line and to perform these operations in a separate unit, as shown in the lower left-hand corner of Fig. 12.9. When this is done, the rolls come from the main line in the form of "Jumbo" reels, which are transported to the embossing and rewinding unit to be rewound into the small consumer rolls. These small rolls are then bundled into units of fifteen or twenty-five and transferred to stock awaiting shipment. This breaking up of the continuous process gives better loading of the mechanical equipment and is more efficient for the short runs and the slower speed production, even though an additional operation is involved.

Making the layout. It is important to have complete information at hand before the actual layout for a plant is made. Such information includes size of production centers; sequence of operations or flow chart; size of storerooms needed for raw materials and partly finished and finished products; space needed for toolrooms; auxiliary equipment; office and production-department requirements; aisle space; recreation rooms; service centers; boiler- and engine-room requirements; and all other similar departments or facilities. Every square yard of space required should be estimated before final plans are prepared. Future expansion must always be borne in mind, and provision made for it. A frequent mistake is failure to provide for expansion or to provide enough space to care for future needs.

An excellent procedure in making a layout is to cut small scaled templets of cardboard or paper representing each machine or group of machines in the process. These should be laid on an outline plan of the building drawn to the same scale. (See Fig. 12.10 for an actual illustration from the General Electric Company.) By this means the almost invariable changes and shifts in plan may be made without expensive and time-wasting drafting work.[3] These shifts are almost always neces-

[3] Mr. H. K. Ferguson of the H. K. Ferguson Company, Cleveland, Ohio, in an address before the American Management Association, November 15, 1939, in Chicago, reports: "My own high mark to date is the making and testing of thirty-four

sary. It is best to proceed very cautiously, watching at all times for unexpected difficulties. When the templets are completed and approved, the whole may be transcribed to blueprints.

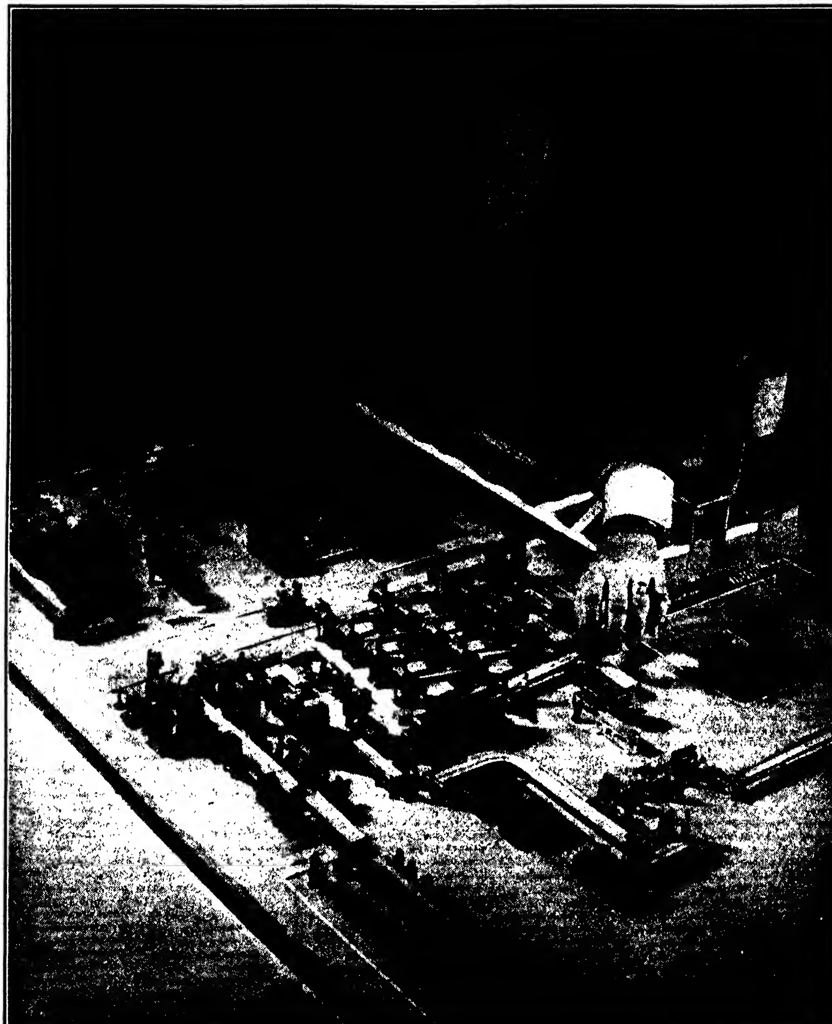


Courtesy, General Electric Company

Fig. 12.10. Using templets to make a plant layout.

Frequently models of equipment and machines are used in making layouts. Figure 12.11 illustrates such a layout of the Westinghouse Electric Corporation, East Pittsburgh Works. Such models give a three-dimensional effect.

alternate layouts for one plant, before arriving at the one, and only one, extremely simple and clean-cut arrangement which most nearly harmonized the ideal and the practicable layout in all particulars."



Courtesy, Westinghouse Electric and Manufacturing Company and "Factory Management and Maintenance"

FIG. 12.11. Three-dimensional layout.

THE FACTORY BUILDING

The ideal modern factory building is developed after all processes are thoroughly considered and related one to another and to the plot of ground which is available. The building is then designed to house these processes. Flexibility in a factory building is a highly desirable objective.

Changes in process and product are constantly taking place. Therefore, although a building should be suitable for the purpose for which it is constructed, it should not be too highly specialized.

The factory building is the primary tool with which to carry on production and into which all other production tools and mechanisms must fit. Like all other tools, the factory building must be adapted to the operations to be performed if these operations are to be most effectively carried on. Defects in factory-building construction are often so primary and organic as to make it almost impossible to remedy them after the building is constructed and production has begun. Hence building defects are often of more continual importance than many disorders in other phases of management, which can be made to respond to executive treatment. An ineffective plant creates a burden in the daily operations of the business.

Plant investment. A desire to increase plant investments may arise from several sources, a few of which are the following:

1. Management desires to have the newest; that is, there is pride in ownership.
2. The present plant is not well adapted to the needs of the manufacturing process.
3. Sales are in excess of the productive capacity of the present plant.
4. Freight rates for the finished product to certain market areas are excessive, and it is thought advisable to locate a plant, usually an additional one, in the market area.

Although a desire for the newest is commendable, it is not justification for permanent commitments in buildings unless these buildings will yield returns commensurate with the expenditures involved. This principle is essentially sound even though funds are available for the expenditure.

If the present plant is not well adapted to the manufacturing process, costs should be compiled to see if the expected manufacturing advantage will justify the increased expenditure. Frequently it will not. It is seldom good judgment to build during the peaks of business prosperity, since costs are always excessive. It is difficult for an aggressive management to vote down new construction after several prosperous years, yet this is most often the most opportune time to postpone additional commitments in buildings.

Building a new plant in another area should not be undertaken without a careful economic survey to check the advantages against the additional costs. Building additional plants in another area raises again nearly all the problems of management, such as methods of control, availability of managing personnel, and expectancy of continued sales volume. It requires much more than available funds to run successfully more than one plant. A shortage of trained executive personnel may readily be the controlling factor in deciding not to expand at a given time.

One of the most difficult managerial problems is to strike a fine balance between investing the available capital in fixed building assets for ultimate return and in the more immediately needed current assets. A safe rule is to consider the plant in the light of a production tool. If the purchase or rent of the new plant may reasonably be expected to yield an increased income over and above all expenses with due regard, in case of purchase, for possible changes in both the product and the process, then and then only should the step be given further consideration. This rule will eliminate many unwise ventures.

Size and type of factory building. The selection of a given size or type of factory building is dependent on many considerations, such as the application of ideals of layout and the location which has been chosen for the factory. Frequently the selection of the plant location will be partly dependent upon factory layout. For instance, if it is determined that a series of small, scattered units is preferable to one large plant, most certainly a suburban location would be carefully scrutinized before being selected, since small plants as a rule are better adapted to the cities or larger towns. The type of building to be erected and the ground space to be occupied are very likely to affect location. As in most management decisions involving policy determination, it will be found that there must be an interrelationship of the factors concerned, and that location, layout, and size and type of factory buildings are closely associated.

The factory-housing problem is very closely associated with the problems of organization. A basic change in the method of housing an enterprise generally results in necessary changes in the construction of the organization in order that supervision may be made most effective. Conversely, a change in organization may at times make it desirable that certain physical aspects of the factory building be modified. For instance, if it is decided to place several departments under the control of one superintendent, it is desirable that these departments be so located that the superintendent may be accessible easily to the foremen of the departments and that he in turn be able to visit the foremen without the loss of too much valuable time.

Building types. In suburban or smaller-city locations, where land is relatively cheap, the one-story plant is often favored, particularly if heavy machinery be used in the processing or if the materials or products are heavy. The maintenance cost arising from the vibrations of machinery operations is largely eliminated in the one-story building, the machinery being set on especially prepared foundations.

Layout problems for processing heavy materials are simplified when consecutive operations are placed at adjacent work places. This arrange-

ment can be accomplished more readily in one-story structures (Fig. 12.12).

Some departments grow more rapidly than others, and the extent of this growth often cannot be foretold at the time of laying out the plant. The one-story plant provides greater flexibility in meeting this condition. Furthermore, provision for the use of natural lighting can be more readily made in the one-story than in the multi-storied plant.

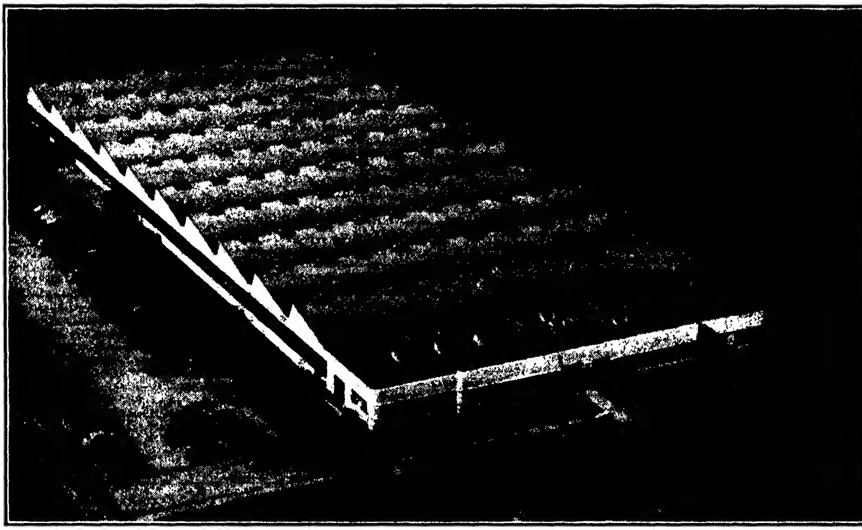


FIG. 12.12. One-story saw-tooth roof building of Paulsen and Nordon, Inc. (Design and construction by the Austin Company.)

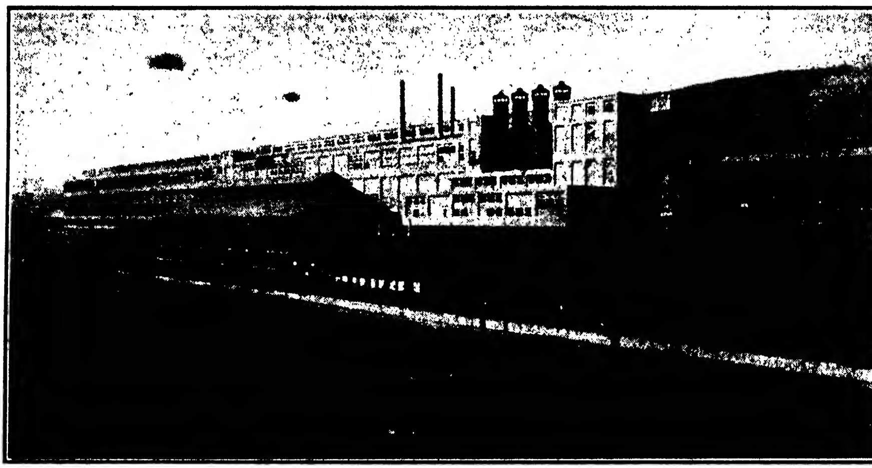
Figure 12.13, illustrating the plant of the Westinghouse Air Brake Company, indicates the manner in which different types of structures are utilized in the same plant to provide necessary housing for the diverse foundry and machine-shop operations of this particular business.

The lowest cost per square foot of floor space can usually be secured through the use of three- to five-story structures if the ground is relatively high in value. Otherwise the lowest cost may be found in one- or two-story structures. With the addition of stories above five or six in a factory employing many workers, the cost per square foot of usable space is likely to increase rapidly, because the effective area is reduced by the service features, such as stairways, firetowers, and elevators. The cost of foundations and the space occupied by supporting columns also increase with the number of stories. When light material, such as hosiery, is handled, a multi-storied building is usually preferred (see Fig. 12.14).

Multi-storied buildings have distinct material-handling advantages where goods can be moved by gravity (see Fig. 13.9, p. 189).

Types of building construction. A simple classification of the various kinds of building construction is as follows:

1. All wood or typical light-frame.
2. Structural steel with hollow tile, brick, concrete, or corrugated metal walls.
3. Reinforced concrete.
4. Slow-burning, heavy wooden or mill construction.



Courtesy, Stone & Webster, Inc.

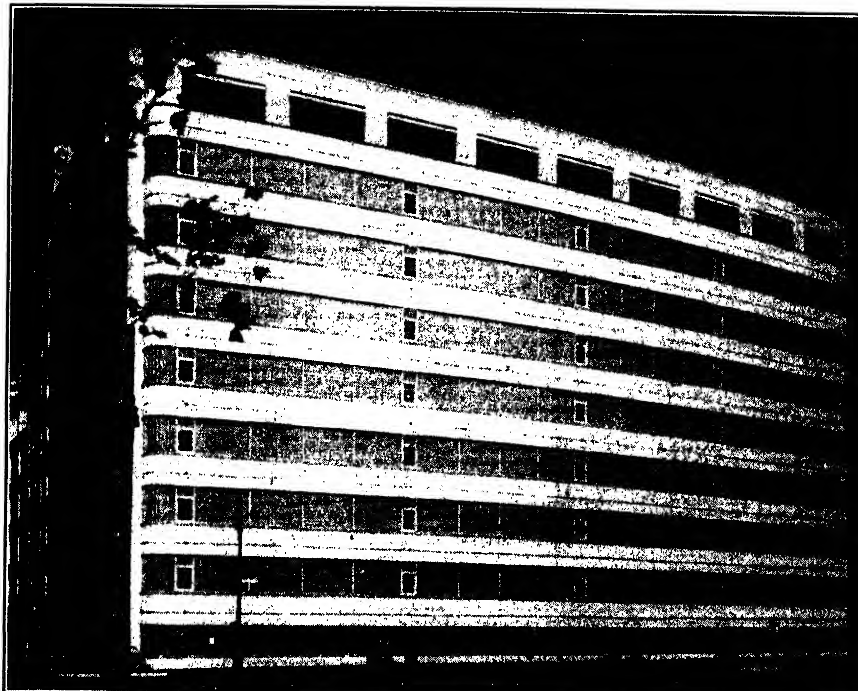
Fig. 12.13. Westinghouse Airbrake Company, Wilmerding, Pa. (A large plant using a variety of types of building construction. Note the saw-tooth roof in the lower right-hand corner and the monitor roof in the front just to the left of the center.)

The structural steel building has the skeleton of steel and the walls and floors of some other suitable material. The reinforced-concrete building is built of concrete and reinforced throughout with steel. The building with mill construction has heavy wooden columns, joists, and other structural members. It was popular when wood was plentiful but is seldom used today. Adequate sprinkler systems must be provided for protection against fire.[4]

The construction used in partitions greatly influences the flexibility of the plant. The tendency is to have as few supporting columns as possible and not to use partitions as a part of the building support. In this case, room partitions and fire walls are often built of hollow tile which can easily be removed and rebuilt as changes in layout require.

[4] See Fernstrom, Elder, Fiske, Schaefer, and Thresher, *Organization and Management of a Business Enterprise,* Harper and Brothers, New York, 1935, pp. 244–252, for a good discussion of building construction.

Determining the size of a factory. It does not always follow that operations must be carried on at one location merely because distinct advantages are inherent in large-scale operations. There are many advantages in the huge multi-acred plant which has come to be looked upon as typical of the new industrial day. On the other hand, there are



Courtesy, Owens-Illinois Glass Company

FIG. 12.14. Multi-storied modern building of the Mergenthaler Linotype Company, Brooklyn, N. Y.

small plants which not only are able to compete with their huge rivals but also frequently produce larger returns per dollar of invested capital. How is this possible in these days of large-scale production, integration, and control of markets of raw material and finished products? The answer lies almost entirely in the management problems involved in operating the large plant in contrast to those involved in operating the small plant. The small plant has certain very definite management advantages which have caused managers of large plants to ask, "How large should a factory be?"

There is a difference in the personnel problem in the large plant and in the small one. No matter how effective the organization or leadership

in large plants, it is impossible for the worker to be in actual contact with the men really running the plant. Many management devices have been instituted for the single purpose of minimizing this impersonal relationship so far as possible. The close relationship between the head of the organization and the worker, which has passed so largely out of industry with the coming of the big corporation, has fostered the survival of many small companies.

Under present economic conditions depressions seem to be inevitable. This fact should influence the size of the plant. Businesses which have several plants are enabled to shut down one of them entirely at such times. Businesses that have but one big plant must shut down a portion of that plant. This course means that the workers throughout the organization are affected because of the shutdown of one small section of the business. They see other men and women thrown out of work, and they naturally ask, "Are we next?" or "Shouldn't we decrease our production so that there will be enough work for all of us?" Although knowledge concerning the partial or complete shutdown of a plant may reach other plants of the same company that are still running and may affect production slightly in an unavoidable way, the effect is far less than that resulting from the shutdown of a portion of the same factory.

Industries manufacturing large or heavy products with nation-wide distribution are always face to face with the freight-rate disadvantages inherent in one large plant, no matter how central its location may be. One of the best examples of a method of coping with this problem, and one that has been largely emulated, is the Ford organization. The location of assembly plants in many parts of the United States, with the product shipped to them from the main factory in knocked-down condition, and the consequent saving of the freight involved proved so successful that the idea was imitated by other automobile companies and other lines of industry. Similarly, in the steel industry more or less rough shapes are shipped to locations near the big cities and are there worked over or "fabricated" in accordance with the needs of the local community.

CHAPTER 13

MATERIAL HANDLING

Material handling, which constitutes one of the largest items of cost in modern manufacturing, can be reduced somewhat by proper layout, as through the use of assembly lines (see Chapter 12), but it cannot be

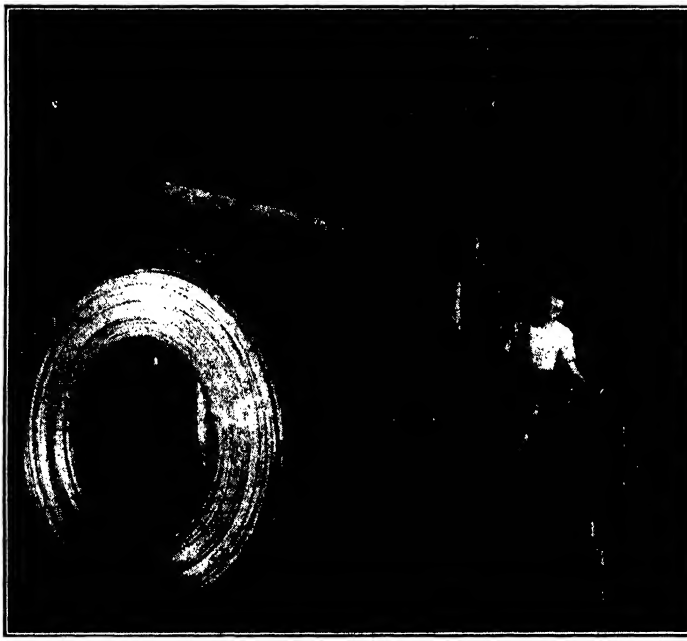
Courtesy, "Automotive Industries"

FIG. 13.1. Handling car doors, Oldsmobile Plant, General Motors Corporation.

wholly eliminated. Modern material-handling methods have reduced these costs greatly, but further economies through the use of improved mechanisms will doubtless make these savings only a beginning in the near future. The United States leads all the other countries in the world in the use of mechanical devices for handling material. This leadership

is due in part to our mass-production industries and in part to high labor costs, as well as the desire to remove drudgery from the work process.

Some material-handling devices promote improved layout by connecting widely separated parts of the factory (see Fig. 13.1); some improve the technique of the process itself; some make possible an increase in the



Courtesy, Jones and Laughlin Steel Corporation

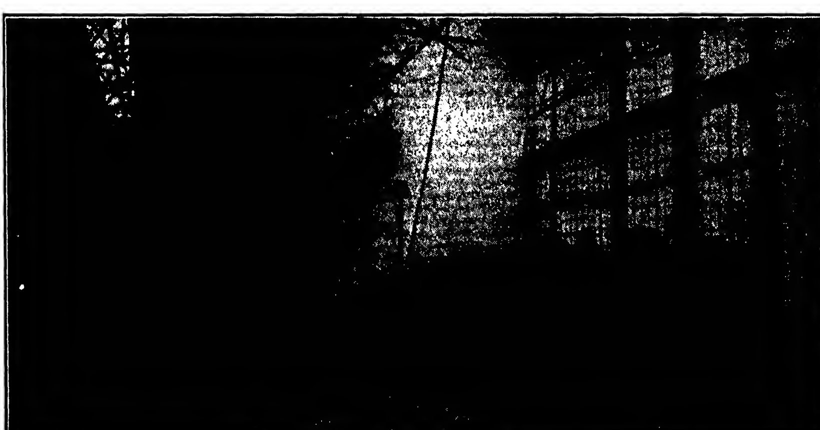
FIG. 13.2. Lift truck moving a 20,000-pound coil.

weight and size of the unit of production (see Fig. 13.2); and some assist in shipping the final product (see Fig. 13.3).

The first developments in mechanical handling included overhead cranes, jib cranes, and locomotive cranes. Overhead cranes still play an important part in material handling. Figure 13.4 shows a craneway in the Chrysler Corporation, Dodge Division. It will be seen that in this craneway freight cars are brought directly within the building, and their unloaded cargo can be transported to any part of the bay by the cranes. The floor is at the level of the car doors. In heavy manufacturing the selection of a site that allows railroad tracks to be placed through buildings, and railroad freight cars to be spotted at any desired point, from which the material may be handled by cranes, is important. Layout of buildings with due consideration for the permissible curves of railroad

Courtesy, Mathews Conveyor Company

FIG. 13.3. Loading freight cars at the plant of Shredded Wheat Company, Niagara Falls, N. Y.

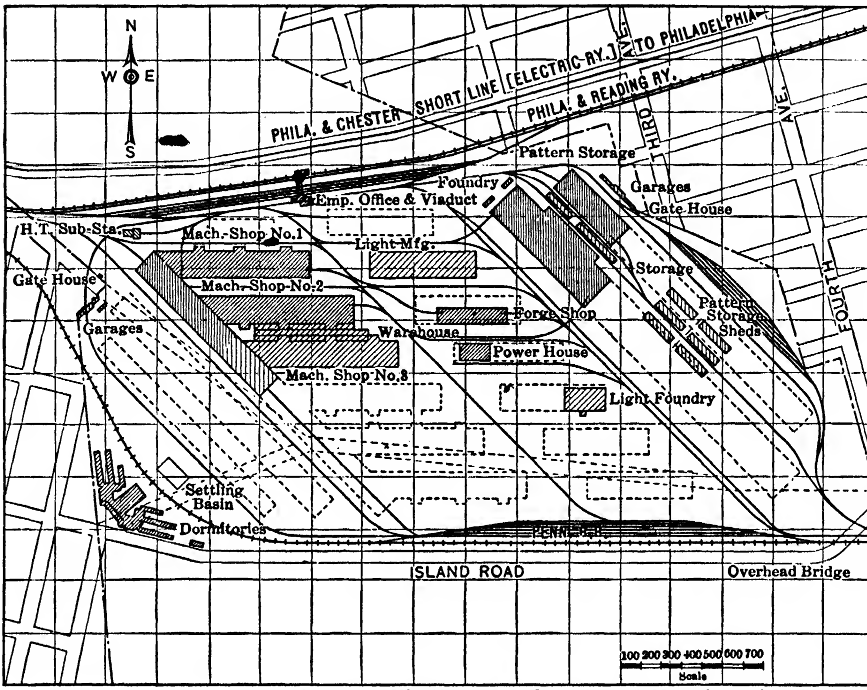


Courtesy, Chrysler Corporation, Dodge Division

FIG. 13.4. Loading and unloading dock inside the building. Note the overhead crane and the fact that the height of the floor is even with a freight-car door.

tracks is a vital factor in material handling within such plants (see Fig. 13.5).

Mechanical unloading devices, such as those illustrated in Fig. 13.6, constitute an important means of saving labor in material handling. In the conveying of bulk goods, such as lumber, and package goods, such as



Courtesy, Westinghouse Electric and Manufacturing Company

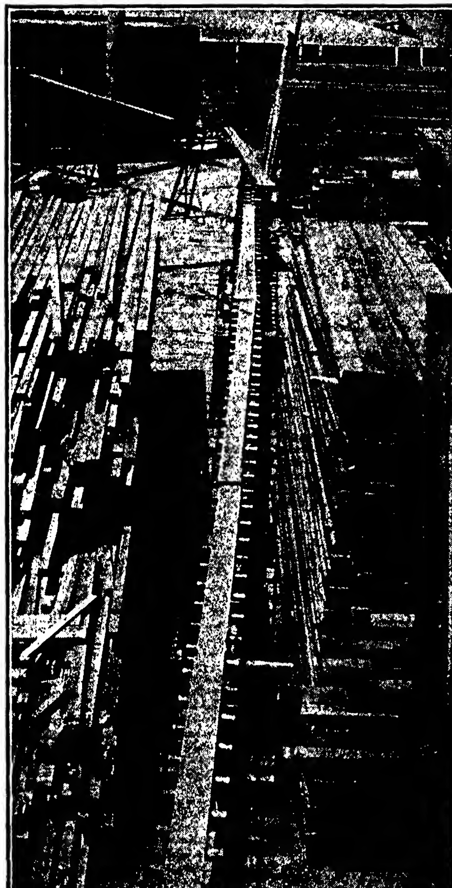
FIG. 13.5. Layout of Westinghouse Electric and Manufacturing Company, South Philadelphia Plant, Lester, Pa. Note the railroad tracks.

those in Fig. 13.3, standard equipment may be used, the only needed adaptation being the securing of proper lengths.

Tiering machines (see Fig. 13.7) and other equipment for handling materials and products in the storeroom are an essential part of such departments. Not only do such devices save labor, but also they allow the materials to be stowed to a greater height.

Plant layout and material handling. In planning a new plant the layout is of prime consideration in outlining the program for material handling. A reciprocal relationship exists between plant layout and material handling. The method of handling materials definitely influences the plant layout, and the plant construction and layout limit the method of

handling materials. When materials are moved by hand-operated or power trucks (see Fig. 13.2), aisles must be provided for their use (see Fig. 12.6). When materials are moved by overhead cranes, as is largely



Courtesy, Mathews Conveyor Company

Fig. 13.6. Three-rail, gravity conveyor, handling lumber at the Mox Lumber & Wrecking Company, Los Angeles, California.

the case in the A. O. Smith automobile-frame plant of Milwaukee when they are not being moved as a part of the continuous fabricating process on the conveyors, aisles are largely missing, but the overhead space must be unobstructed. When materials are moved by pipe lines or ducts, as paint is in automobile-body plants (Fig. 13.8) and shavings and sawdust are in woodworking plants, provision must be made for these methods of transportation. Multi-storied buildings may require elevators or lift-

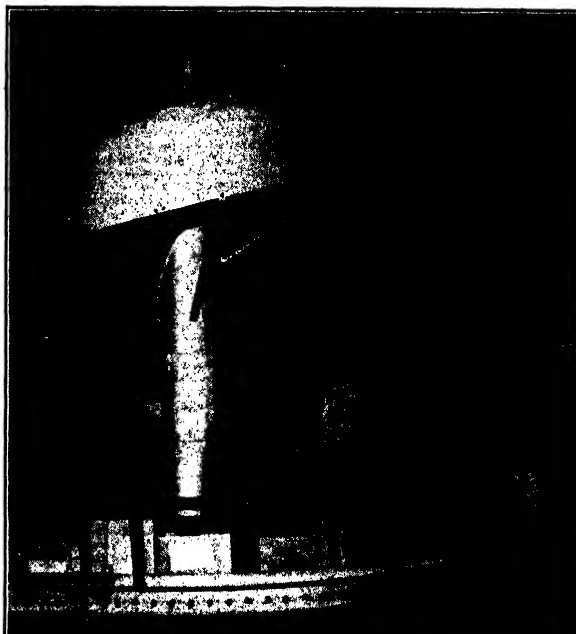
Courtesy, Union Metal Manufacturing Company, Canton, Ohio

FIG. 13.7. Tiering truck stacking skid boxes that have floor-channel runners.

Courtesy, "Steel"

FIG. 13.8. Circulating paint to spray booths through pipes illustrates a modern material-handling method in automobile-body plants. Standardized materials, as well as lower handling costs, result.

conveyors of a different construction than the material-handling equipment needed in a single-story building in which the same operation is performed. Gravity may be utilized in moving materials in a multi-storied building or one built on a sloping grade (see Fig. 13.9). Modern material-handling techniques make possible a continuous flow of materials and work in process between buildings and from one floor to another, thus re-



Courtesy, Walgreen Drug Stores

FIG. 13.9. Spiral chute.

moving restrictions of space and building construction that formerly handicapped the industrial engineer's plans. The ideal processing sequence may now be visualized and, by applying known techniques, may be largely realized in spite of serious handicaps of building construction.

Processing and material handling. Material handling is an integral part of the manufacturing process in many instances of modern mass production. In the cement industry and in flour mills, simple conveying devices have been an essential part of the process for many years. The meat-packing industry was one of the first to use mechanical conveyors to support the product while operations were performed upon it (see Fig. 13.10). Such conveyors change the process from an intermittent to a continuous one and provide for constant utilization of labor and equip-

ment. This use of material-handling equipment is well illustrated by the continuous assembly and testing of washing machines, radios, and other products.

The automotive industry was one of the first to apply mechanical process conveying of materials on a large and varied scale. This industry

Courtesy, Westinghouse Lamp Company

FIG. 13.10. Meat cutting on a conveyor. (150-watt white bowl lamps with RLM Reflectors produce 12 foot-candles on the table. Adequate light is needed for this hazardous operation.)

does its processing, whenever possible, as the material moves (see Fig. 13.11) and has applied mechanical handling to all phases of material handling (see Fig. 13.12). The moving-chain conveyor and its counterparts play important roles in determining rates and costs of production in this industry. The lowering of prices and consequent enlargement of the market which accompanied the use of process conveyors in the automotive industry is an outstanding development of manufacturing in the twentieth century and has encouraged other industries to endeavor to perfect similar production economies.

The mail-order houses in Chicago were the first to apply the principle of material handling to the filling of orders. As a matter of fact, material handling is as completely developed in the mail-order business as in manufacturing. Many mail-order men claim that the automobile industry learned some of its techniques from them. In the mail-order business

Courtesy, Buick Motor Division, General Motors Corporation

Fig. 13.11. Buick automobiles rolling off the assembly line.

orders from the customers are opened by a group of order readers seated along a conveyor.

Much of the heavy manual labor in foundries has been eliminated by the use of material-handling devices. Although common labor has not been eliminated entirely, it has been greatly reduced. Figure 13.13 illustrates the application of hoppers in this industry. In the Buick Foundry (see Fig. 13.14) intake and exhaust pipes are turned out at a speed undreamed of under the old hand-operating methods. For large-volume production of castings the Allis-Chalmers Corporation of Milwaukee has also introduced conveyors for the pouring of molten iron into the molds. Figure 13.15 illustrates material handling in the steel industry. The

application of the process conveyor in other industries is shown in Fig. 13.16.

Figure 13.17 illustrates a simple chute type of conveyor used by the General Motors Corporation to transfer tires from the balcony to the automobile assembly line.

Courtesy, General Motors Truck and Coach Division

FIG. 13.12. A simple chute that works.

Another method of transporting materials is shown by Figure 13.8. This is an ultramodern method of bringing the automobile paint from the paint-storage and mixing room to the spray booth.[1] Automobile body doors are transferred from the door department to the body lines by overhead conveyors, as is illustrated in Fig. 13.1. Figures 13.18, 13.19, and 13.20 show interesting devices for handling materials.

Although process conveying is the outstanding feature of material handling today, great strides have been made in other methods of handling

[1] The principle of piping materials is used extensively in external transportation. Gasoline is piped all the way from the oil fields of the South to Chicago. Natural gas is also piped from the South to Chicago.

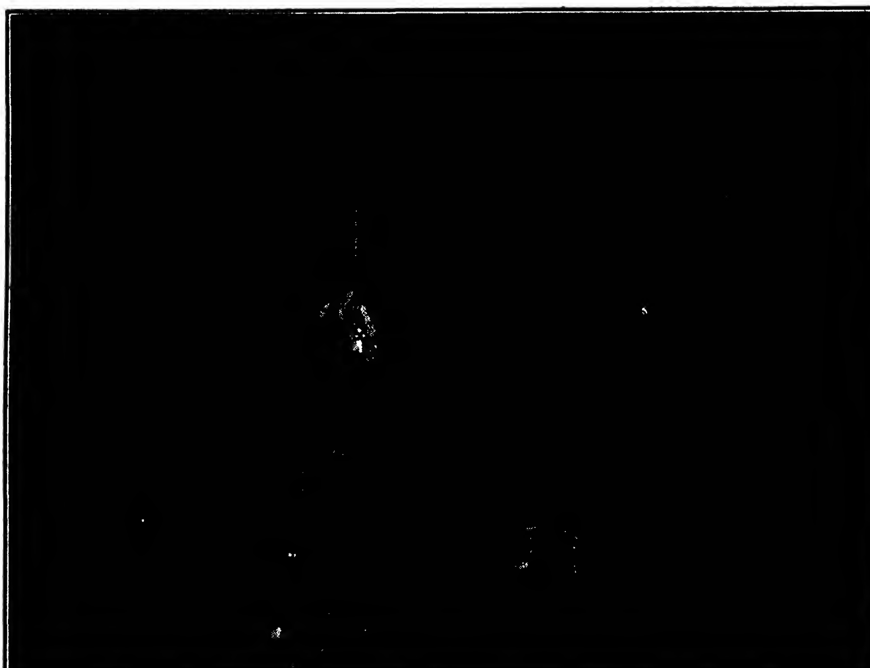
materials that have not been mentioned specificially. Material handling by modern methods is an important factor in the lowered production costs of mechanized industry. Road building and the entire construction industry make extensive use of mechanical devices for this purpose.

Courtesy, the Perfect Circle Company, Hagerstown, Ind.

Fig. 13.13. Overhead hopper or bin for sand in the foundry-moulding department.

Material handling between plants. Long-body trailers are familiar sights on the roads between Detroit, Pontiac, and Flint. Haul-away automobile trucks are seen in many parts of the United States. To handle body stampings and other automobile parts the Ford Motor Company has specially equipped freight cars in which they ship supplies to the Chicago assembly plant from Dearborn. In many cases they have found it cheaper to return these cars to Dearborn empty rather than to disassemble the special supports, braces, and clamps that hold the parts in place. Special consideration is given to the design of parts that make up

the finished product, their transportation from central manufacturing plants to the various assembly plants being kept in mind. It is no exaggeration to say that material-handling techniques have definitely influenced plant location in some industries. The Ford Motor Company makes extensive use of water transportation between Dearborn and Chicago during the lake-transportation season.



Courtesy, "Automotive Industries"

FIG. 13.14. Moulding machines for moulding intake and exhaust pipes, together with material-handling equipment, Buick Motor Car Company, Flint, Mich.

Volume of production and material-handling methods. As in machine operations, the volume of production of a particular article or type of article is often a controlling factor in the method adopted for handling material. A conveyor may be too expensive to use for handling small volumes, from the standpoint not only of invested capital but also of labor. It is often necessary to have one operator load a conveyor and another one remove the item conveyed. This arrangement is frequently used in spite of automatic unloading devices. The automatic unloading device will remove the article from the conveyor, but it seldom stores it away. Some articles cannot be allowed to pile up on each other. Another situa-

tion arises when certain items are produced in sufficient volume for mechanical conveyors to be used, but other similar items in the same plant cannot be thus efficiently handled. For instance, in its Chicago plant the Ford Motor Company dips its black fenders in paint by means of a conveyor but dips other colors, not run in sufficient quantities, by hand. In

Courtesy, "Steel"

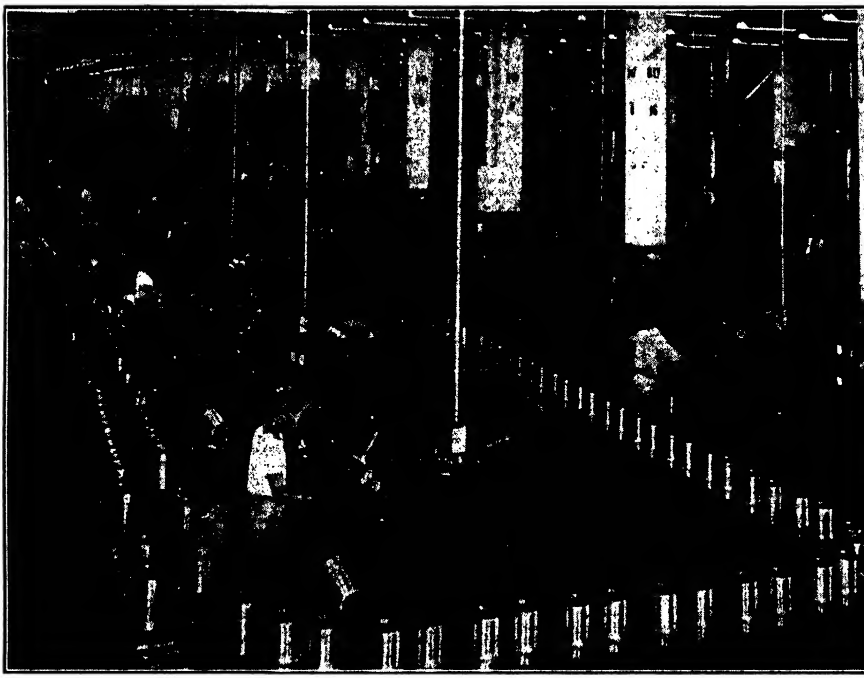
Fig. 13.15. Handling coils of wide strip steel at the beginning of modern continuous pickling machines. (The crane and magnet drop the coils on the conveyors, which take them to the tilting table. From there they are skidded to the decoilers and then are fed through the continuous pickling tanks.)

one plant automobile seat cushions may be assembled on a moving conveyor, and in another plant owned by the same company these same cushions may be assembled on benches because of the lower volume of production.

Material handling and the worker. It is not unusual to find that a particular article can be moved as quickly or even more quickly by manpower than by some mechanical means, yet a mechanical method is used to reduce the physical strain on the worker. Sometimes a machine operator obtains his material and returns the finished product to a central place not because these jobs can be done better by him than by mechanical means or by a special trucker, but as a means of breaking the monotony of his work or reducing the fatigue of sitting in one position for too long

a period. This practice is frequently followed in the clothing industry, such as in making men's clothing.

Material handling and the industrial engineer. One of the first places that the industrial engineer looks for savings is in the method of handling materials. The plant and process engineer give this important item careful attention in their initial plans. The present science of engineering has reduced material handling to such a simple subject that it is easy to find a suitable method for handling almost any item. Material handling requires careful study of each situation rather than the application of a single method to fit all situations. The manufacturer of material-handling equipment usually can combine stock items into a multitude of variations to meet almost any requirement. Writing in the October, 1945, issue of *Factory Management and Maintenance*, Walter F. Eitel listed the following items to be checked before making changes in material-handling methods:



Courtesy, Wright Aeronautical Corporation, a division of Curtiss-Wright Corporation

FIG. 13.16. A conveyor in a mass-production machine shop.

1. Can purchased material be furnished to operator in original shipping containers?

Courtesy, General Motors Corporation

FIG. 13.17. Tire chute conveyor from the balcony to final assembly in one of the General Motors automobile assembly plants.

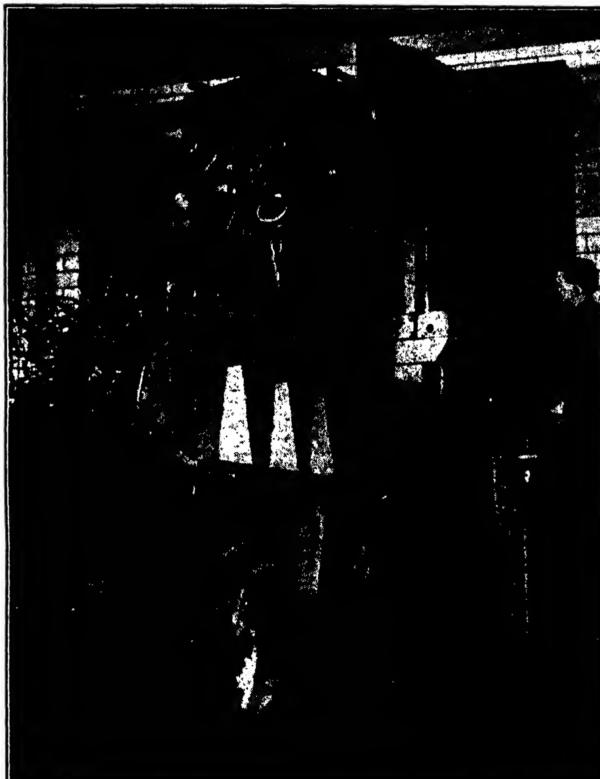
2. If not, can vendor change containers?
3. How often is material handled from receiving dock or a previous operation until used again?
4. Does operator lose much time handling material to and from operation?
5. Does this loss affect the line balance?
6. Are the containers best suited for the purpose?

Courtesy, the Ohio Electric Manufacturing Company

FIG. 13.18. An electric magnet lifting a heavy load of steel.

   a. Are they too large and heavy?
   b. Are they too small, with not enough capacity?
   c. Are they difficult to pile?
   d. Is it necessary to remove material from container and place in hopper?
   e. Could this be avoided?
7. Would it be advantageous to have a stockman?
8. Should material be handled in lots?
9. Should material be handled in units?
10. Are trays, hangers, or racks needed?
11. Are they of proper design?
12. Does operator have to wait for stock?
13. Should chutes be provided?
14. Should a conveyor be installed?
15. If so, for what purpose is the conveyor desirable?

a. To supply material?
b. To store material?
c. As assembly conveyor?
d. *A* combination?

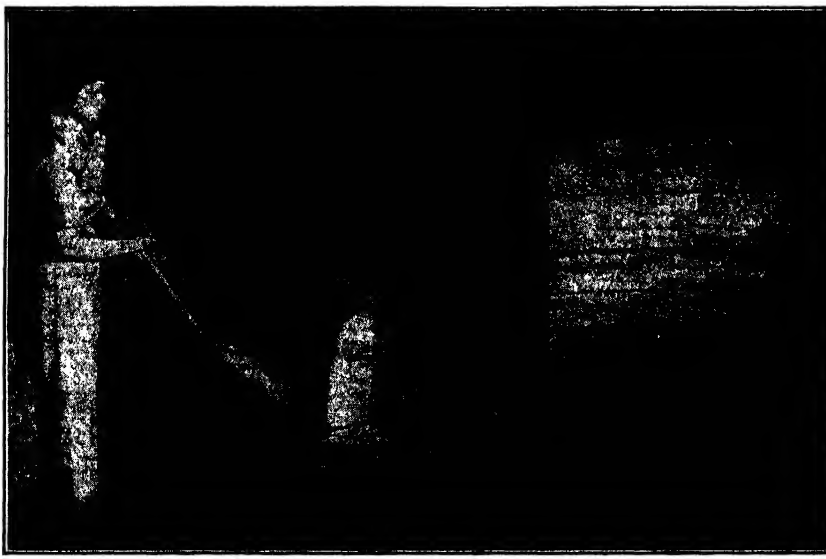


Courtesy, Allis-Chalmers Manufacturing Company

FIG. 13.19. A high-lift electric truck with the forks on a swivel can mechanically dump the skid box.

16. What type of conveyor is most suitable?
a. Roller conveyor?
b. Belt conveyor?
c. Bench conveyor?
d. Monorail conveyor?
e. Gravity conveyor?
f. Chutes?

17. Should a truck be used?
    a. Hand truck?
    b. Power truck?
18. Is handling of scrap satisfactory?
19. Is handling of oil and compound satisfactory?
20. How often is the finished product handled before it is ready for shipment?



Courtesy, Automatic Transportation Company, Chicago, Ill.

FIG. 13.20. The power-driven "Transporter" enables a woman to handle heavy loads of castings.

CHAPTER 14

MACHINES AND EQUIPMENT

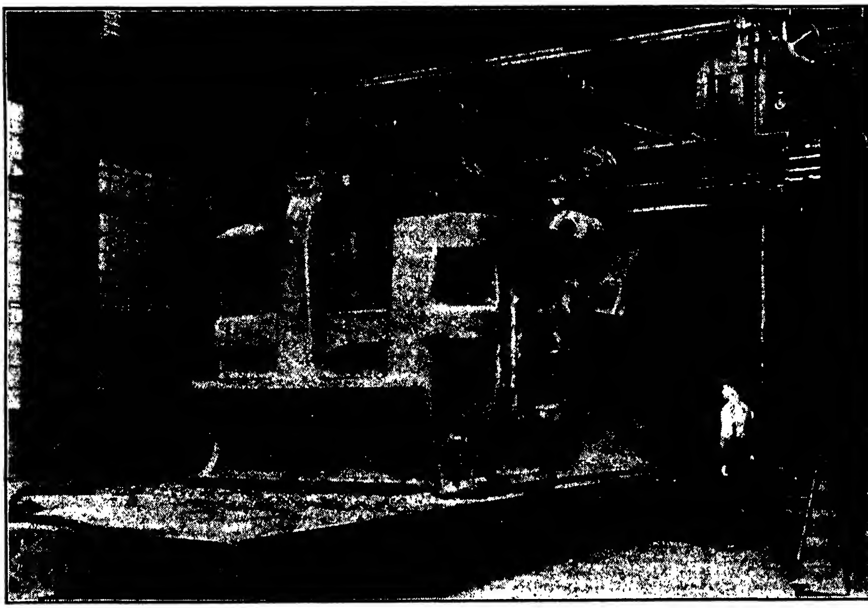
The age of machinery. Our present era has been successively called the *machine age*, the *age of electricity*, and the *chemical age*. Each of these names characterizes a phase of the material culture that seemingly was in the ascendency at the time of its use. There is a great measure of justification for each of them, although basically the *machine age* is more truly expressive of the real situation than either of the others. The utilization of electricity, the chemical achievements of the present, and the possible utilization of nuclear energy rest solidly upon man's ability to multiply his efforts through the instrumentality of the machine.

Watt clearly demonstrated the principle of the steam engine several years before he was able to construct a producing machine, for the very simple reason that there were no machines sufficiently accurate with which to make either the cylinder or the piston. The steam engine had to await the development of a boring machine before it could become a reality. The same situation exists today. The marvels of electricity are dependent upon the ability to make the motor generators that produce the current.

Machine tools. Machine-tool manufacturers produce the machines that are used in making the production tools and dies needed for manufacturing consumer goods. The basic tools used in making production machines are the lathe, shaper, planer, drill press, milling machine, and more recently the precision grinder. It is also true that these same machines are used with special adaptation for production purposes. The manufacturers and their workmen are master craftsmen, working with close tolerance and great ingenuity. The great Allis-Chalmers Manufacturing Company at Milwaukee produces gigantic production equipment used in industry (see Figs. 14.1 and 14.2). Its operation would be impossible without the marvelous machine tools with which to work.

The plant as a machine. As was pointed out in Chapter 12, in mass production the plant itself is frequently a giant machine made up of a series of synchronized individual machines. The automobile-frame plant of the A. O. Smith Corporation in Milwaukee is probably the best illustration of the plant as a semiautomatic machine. Strip steel is unloaded from the freight cars by machinery, is inspected for gauge, width, and

length by machinery, and progresses through these many operations with the hand of man seldom touching it. Even the thousands of rivets used daily are inserted in their holes automatically through pneumatic tubes, into which they are fed automatically through a hopper. As the frame moves from station to station along the conveyor, the riveting machines move into position, clinch the rivets, and again move back out of the way



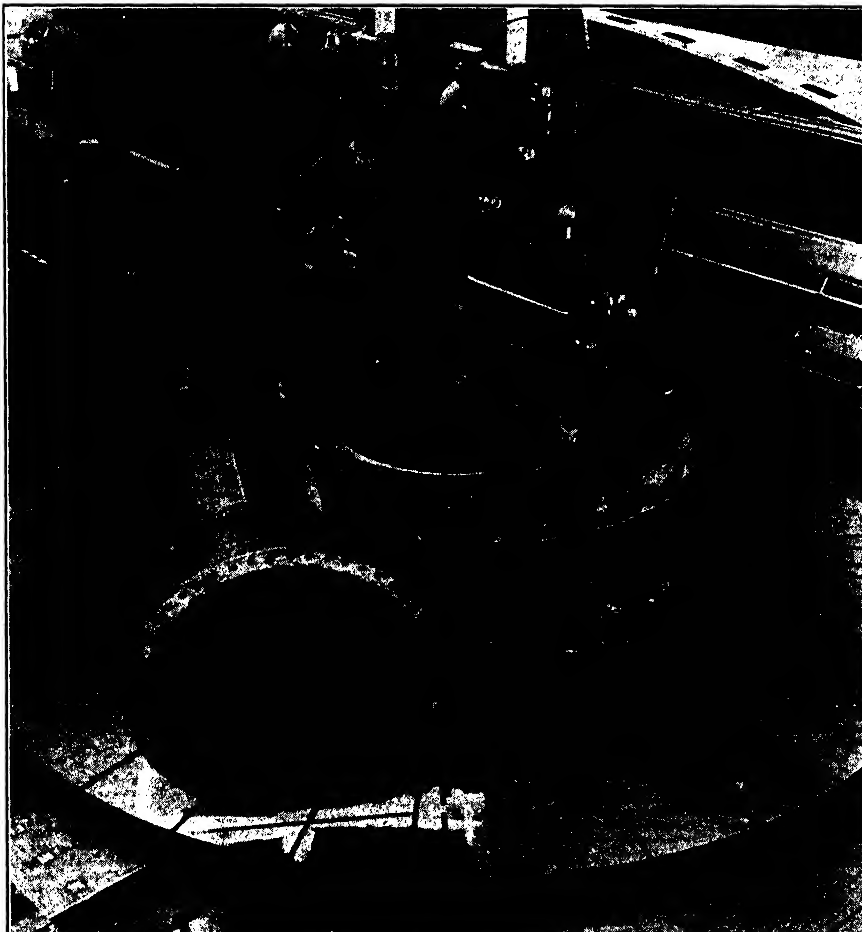
Courtesy, "Steel"

FIG. 14.1. Casting weighing 152,000 pounds for the bed of an upsetting forging machine being machined on a planer at the Allis-Chalmers Manufacturing Company, Milwaukee, Wis.

until the next frame comes into position, when the riveting machines again repeat the cycle. It is truly a plant operating as an automatic machine.

Standard equipment. Equipment may be thought of as everything, except material, with which the worker is provided to aid him in the performance of his task. The building itself is a most important phase of equipment, but usually it is not referred to as such. Equipment ordinarily includes all apparatus assigned to production centers at which employees work, including workbenches or machines, and all tools, either separate from the machines or fitted into them as particular jobs are to be done. Standardization of equipment, like that of tools, is important, not only as a basis for rate setting but also because of the economies of utilizing equipment best suited to its task.

Standardization of equipment tends very definitely to reduce maintenance costs in that the maintenance workmen become more familiar with the peculiarities of standardized machines, and the inventory of repair



Courtesy, Allis-Chalmers Manufacturing Company

Fig. 14.2. A 40-foot boring mill showing riveted spiral casing for a hydroelectric unit. The size of this machine can be appreciated by comparing the spiral casing with the height of the man standing in the center.

parts that must be carried for emergencies is reduced. This inventory factor is no small item. It manifests itself in two ways. In the first place, if the machines are too varied, the keeping of repair parts becomes so complicated and costly that an adequate supply of parts will seldom be on hand. When this situation prevails, breakdowns become very costly, since

production will be tied up unnecessarily or overtime has to be paid. In the second place, if adequate repair parts are kept, the total number is much greater for varied machines than for standardized ones.

Economies of production are realized by the use of standardized equipment. Men become accustomed to working with a given type of machine and can be transferred from one to another with relatively little loss in efficiency when the machines are standardized. This fact contributes to flexibility in the use of manpower.

It should not be inferred that standardization of equipment requires all machines of the same general type to be alike. As far as practicable, however, all machines performing the same identical operation should be alike. A six-inch production lathe will be used where the work requires this size, and a twelve-inch lathe where the work requires that size. Occasionally a six-inch operation may be performed on a twelve-inch lathe when the other machines are in use. The matter of *balance in the selection* of equipment is not always easy. At one time a department may be in perfect balance as far as sizes and types of machines are concerned and a year later, when conditions have changed, be out of balance.

Working toward standardized equipment. Improvements are continually being made in both the machine tools and special-purpose production machines. When a manufacturer decides to standardize his equipment, he may be faced with the problem of what to do with his present equipment. The economies gained occasionally will justify standardization even at the cost of selling the old equipment at whatever price it will bring. Often this is not the case, yet it does not preclude a definite decision to standardize. Instead of replacing at one time all the present machines with the type decided upon for standardization, the desired equipment can be installed gradually as the older equipment is worn out. It may take some time to complete the standardizing process, but this goal is one toward which good management strives.

Special-purpose equipment versus standard machines. Standard machines, such as the lathe, grinder, planer, shaper, and drill press, have certain very definite advantages over special-purpose machines. "Standard," in the sense that it is being used here, refers to the general-purpose machine. (It is possible to standardize the production of special-purpose machines.) A few of the advantages of the standard or general-purpose machines are as follows:

1. Less initial investment in equipment. The standard machines usually cost less, largely because they are produced in larger quantities and the cost of engineering is spread over a larger number of machines.

2. Greater flexibility in the range of the work that can be done.

3. Possibility of smaller number of machines being required to meet production needs, as a result of the increased flexibility (see Fig. 14.3).

4. Greater ability to meet requirements of changes in design of the product or even a complete change in the nature of the product.

5. Easier maintenance of balance in the equipment required and less dependence upon mass production.

Courtesy, General Motors Corporation

Fig. 14.3. A radial drill being used on a fixture for mass production. The radial drill is a general-purpose tool, highly flexible for work that is not particularly repetitive.

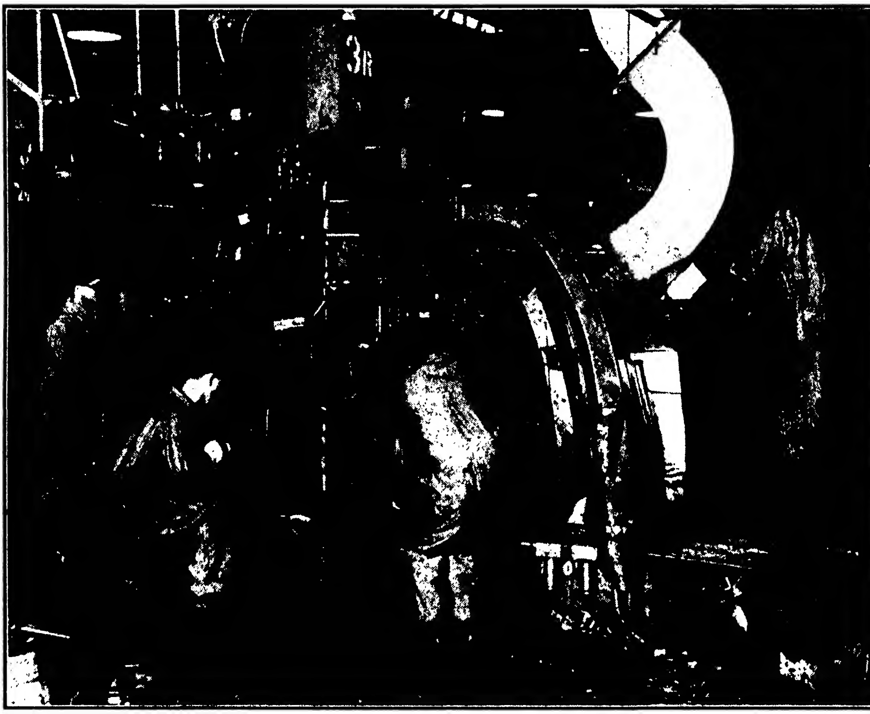
6. Less expensive maintenance, in that repair parts cost less and require less skill to install.

In the case of special-purpose equipment certain conditions must prevail in order to justify the expenditures necessary for installation. These conditions are:

1. It is necessary that the market for the product be large enough to absorb the output of the special-purpose equipment.

2. The product must be well standardized to make use of the special production machines (see Fig. 14.4).

3. Style and technical changes should be infrequent or volume should be sufficiently large to amortize the cost of the equipment in a short time, as in the automobile industry (see Fig. 14.5).
4. It is highly desirable that seasonal and cyclical variations in production be reasonably low.



Courtesy, "Automotive Industries"

FIG. 14.4. A "setup buck," where five component body parts are welded into a single unit. (Specialized production fixtures have attained a maximum of complexity and simplicity of operation in the automotive industry. Note the suction pipes drawing fumes from the interior as the welding progresses.) Pontiac Motor Company, Pontiac, Mich.

5. Sufficient funds must be available to absorb the high fixed capital investment (see Fig. 14.6).

Where most of the foregoing conditions prevail, special-purpose equipment has many advantages, among them the following:

1. The quality of the product tends to be more uniform.
2. Inspection costs are reduced.
3. A semiskilled operator usually can be substituted for a more highly skilled man.
4. Output per unit of time is greatly increased, thus reducing the direct labor costs.
5. Factory floor space is usually less for the same volume of production.

6. A reciprocal relationship tends to exist among labor specialization, process specialization, and machine specialization.
7. Unit costs tend to be reduced.

The disadvantages of standard-purpose production equipment are in substance the advantages of special-purpose machines, such as less

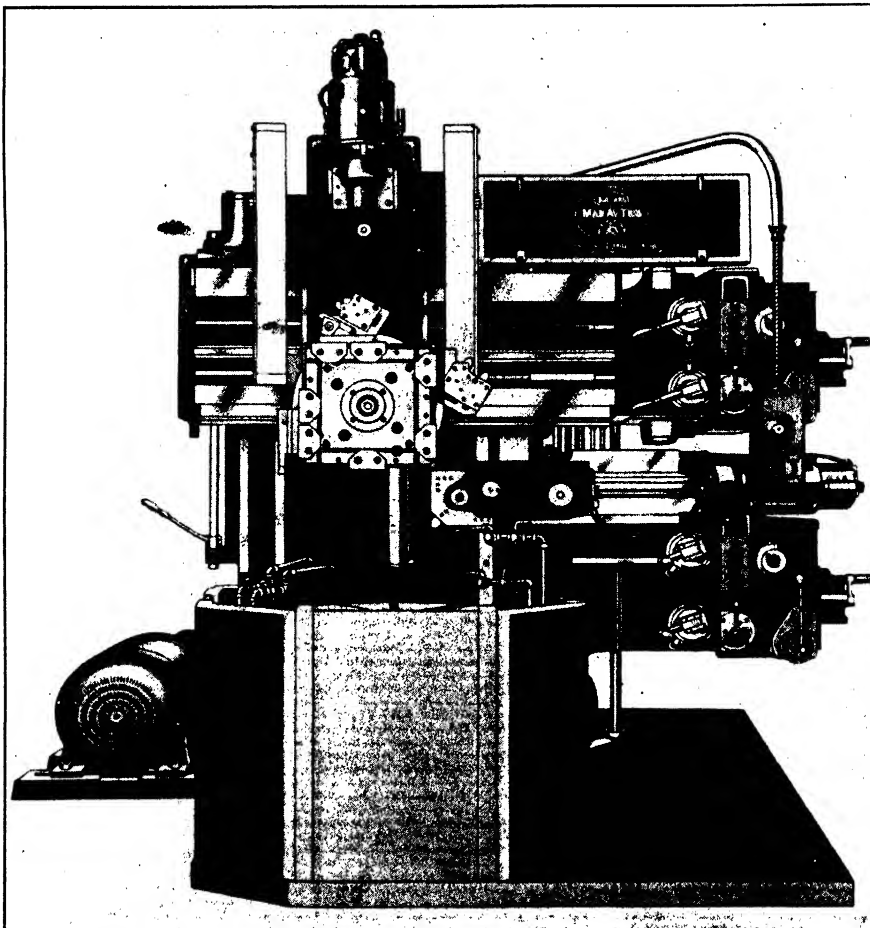
Courtesy, "Automotive Industries"

FIG. 14.5. Welding fender halves in a specialized welding machine producing a 90-inch flash-welded joint in seven seconds. Pontiac Motor Company, Pontiac, Mich.

flexibility, increased capital investment, increased maintenance costs, greater difficulty in maintaining a balanced relationship in equipment. Management is constantly faced with a choice between the general-purpose machines and the special machines. The volume of production and available funds bulk large in the final determination of the problem. Frequently a compromise between maximum specialization and general-purpose equipment is reached.

Adapting general-purpose equipment to special-purpose requirements. In attempting to compromise between the expense with the attendant hazards of extreme specialization of equipment and the low production and high direct labor cost of general-purpose machines, some managers

have sought to adapt standard machines to special purposes. Probably the best-known instance is the machine built by the A. O. Smith Corporation of Milwaukee to machine the fittings for the automobile frame. The



Courtesy, the Bullard Company

FIG. 14.6. A 36-inch Bullard Man-Au-Trol vertical turret lathe. When properly tooled, this is a high-production special-purpose machine.

various units of this machine which performed the different drilling, reaming, tapping, and milling operations were built to be interchangeable with each other on the machine base.[1] The various operating units of the

[1] See Franklin E. Folts, *Introduction to Industrial Management*, McGraw-Hill Book Company, New York, 1938, pp. 54–56; also *Bulletin No. 210*, A. O. Smith Corporation, April, 1929, p. 13.

machine could be assembled in whatever order or sequence the individual parts required. This was necessary because all the parts did not have the same operations. When the adjustments had been made, the machine was automatic. The respective operating units were largely general-purpose machines; special bases, however, had to be made for these machines, since their manufacturers did not have standard interchangeable bases.

Another method of approaching the economies of special-purpose machines while using general-purpose equipment is to connect the general-purpose machines by automatic feeds and conveyors and synchronize their operations by some timing device, either mechanical or electrical. The machines retain their flexibility, in part at least, and the timing devices and fixtures are essentially the only special features, since the conveyor equipment is frequently adaptable to various machines. For instance, two automatic screw machines have been connected by a take-off, transfer, and loading device in such a manner as to complete a part as if it were being manufactured by one machine.[2]

Changes that have influenced machine-tool design and use. Machine tools and production tools are undergoing improvements all the time. Part of this advance has been the direct result of research on the initiative of the machine builders, and part has arisen from changes which they have had to meet but for which they were not responsible. For example, the carbide tools will stand up under higher speeds, and the machine builders had to design their machines to stand up under these new speeds. The use of higher-alloy steels of greater strength and the accuracy of gear forms have permitted the use of smaller mechanical units of higher speed to fulfill the same functions that previously required larger mechanisms. Many manufacturing functions previously requiring machining operations are now being performed by other methods or at least with less demands on the machine tools. Foundry castings are being produced closer to size, thus reducing the amount of metal that has to be removed. The same result has been achieved by the improvements in forgings. Finishing flat surfaces by coin pressing and producing forms by press work or by surface broaching have changed the machining requirements considerably. Grinding, particularly of rough castings, has greatly reduced the amount of metal that was formerly removed by boring, turning, and facing. Die casting of parts not requiring great strength has also greatly reduced machining requirements (see Fig. 14.7). With the shorter productive cycle greater emphasis has been placed on the nonproductive functions that are necessary in machine operations. In some instances

[2] See *American Machinist,* August 30, 1945, p. 107.

these have become automatic or semiautomatic or have been appreciably reduced by mechanical helps.

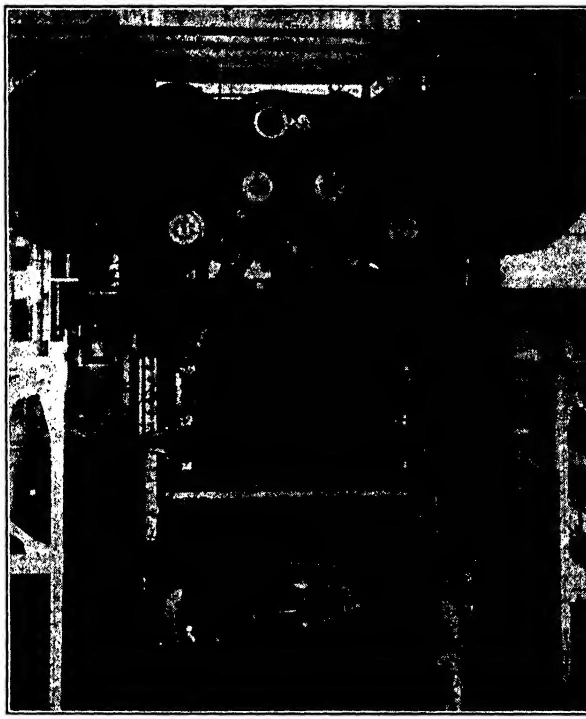
Amortizing equipment costs. In order to improve quality new expenditures will frequently be incurred with the hope of placing the product in a better competitive position, even though the equipment may not show any direct manufacturing economies in the immediate present. The same situation holds in connection with improving working conditions which involve either safety or health. However, most expenditures are carefully checked against the anticipated savings in manufacturing costs. If special-purpose machines are to be used in the manufacture of a product having a high style factor, it is customary to require that the machine pay for itself in a relatively short time, especially during the expected life of the particular style for which it was designed. In the automobile industry the special tools, dies, and fixtures are expected to pay for themselves during the life of the current model, which is usually one year. On the other hand, the more general-purpose equipment is expected to pay for itself during its effective life. General-purpose equipment in this sense does not have to be in universal but must be in general use in the particular industry. For instance, the gigantic press shown in Fig. 14.8 is in reality used in relatively few industries, yet its reasonable life expectancy in the automobile industry is not less than ten years. Likewise the large Keller die-cutting machine shown in Fig. 14.9 has a relatively long life.

Courtesy, Precision Casting Company and "Automotive Industries"

FIG. 14.7. Die-cast automobile radiator grilles.

Standardization of work place. Work places may or may not include machinery, depending upon whether the operation is performed by hand or machine. In machine operations the work place is largely determined by the nature of the machine. In tending spinning frames or looms, the work place does not usually include a chair as part of the standard equip-

ment, because the nature of the operation does not give the worker much opportunity for sitting down. In many cases, six, eight, or more looms are attended by a single operator, and the job consists largely of walking from one to another and seeing that everything is running smoothly. On the other hand, when standard machines work on products which allow



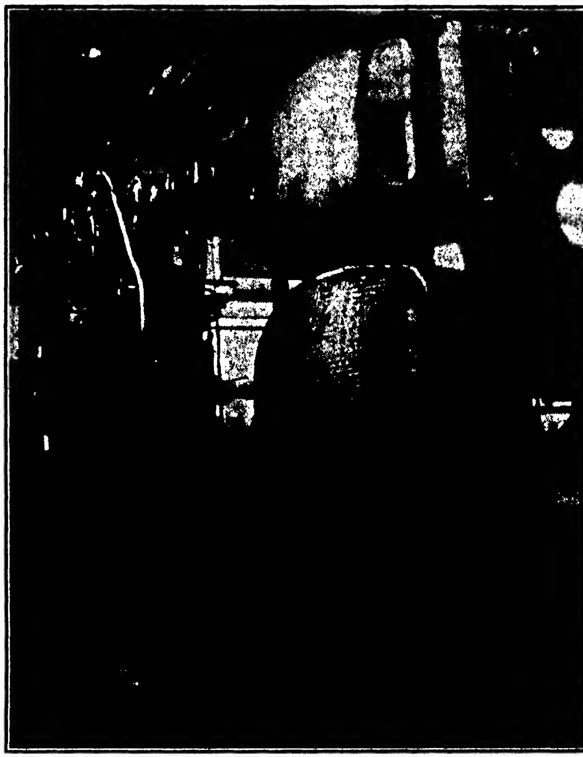
Courtesy, "Steel"

FIG. 14.8. Eight-hundred-ton press used in shaping rear panels for sedan bodies at Ford Motor Company Rouge Plant, Dearborn, Mich.

the worker to remain seated, the seating arrangements become a portion of the standard work place.

Standardized work places come to be of particular value in hand work, such as the assembly of small products. Figure 14.10 illustrates a standard workbench for the assembly of typewriters. Each of the small parts that goes into the final assembly has its particular compartment, built to fit. These compartments are so arranged that the article may be removed by the left or right hand, depending upon the sequence of operations while it is being assembled, or which hand should carry it to the assembly. Small screws and nuts are conveniently held by standard parts-carrying

boxes that fit into the top of the assembly bench. Motion economy sometimes requires that the same small part be in two positions on the bench if it is used in more than one place and is picked up and handled by both hands simultaneously, or possibly in a different sequence.



Courtesy, "Automotive Industries"

FIG. 14.9. Die-making on a large scale with the Keller die-cutting machine. This huge die for one-piece body top is made of nickel-chromium iron with alloy steel inserts at wearing parts. The cutting tool of the Keller machine is guided by the finger which passes over the mahogany master model, above the die. Koestlin Tool and Die Corporation, Detroit.

Figure 14.11 shows a slightly different type of standardized arrangement for assembling small parts to be sent to the assembly line.

Standard equipment other than machines. Equipment to hold parts for assembly has been developed by many companies to fit their particular needs. Figure 14.12 illustrates such a box, utilized at the Philadelphia plant of the General Electric Company in the assembly of small switches. Several parts, usually 25, are provided for each lot being manufactured. If one part, for instance, a screw of a particular size, is used twice in the

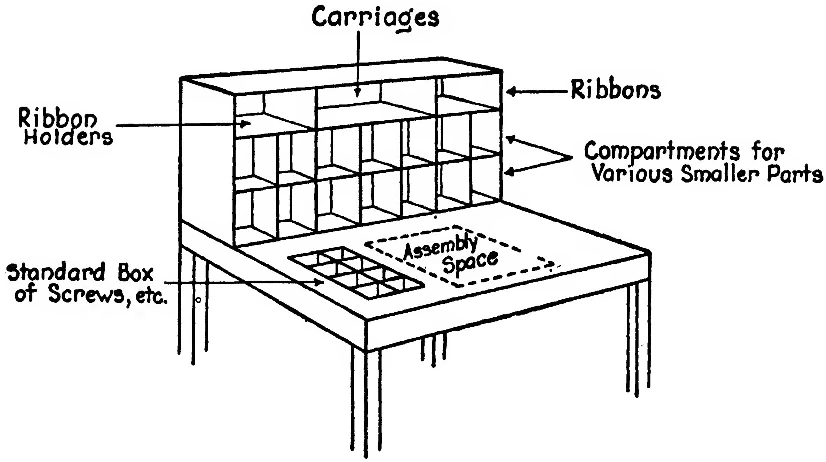


Fig. 14.10. Standardized assembly bench, L. C. Smith & Corona Typewriters, Inc., Groton, N. Y.

Courtesy, Kollsman Instrument Division, Square D Company

Fig. 14.11. A work place, showing an operator using an automatic hopper to load such parts as screws, pins, and washers into bottles. Racks of bottles are then sent to loading benches to be placed in tote boxes. (See Fig. 15.12.)

assembly, twice the number of this part is provided. Much study may be given the arrangement of the divisions of the boxes, so as to entail the least labor in assembling. Another type of box is the standard metal tote box, which has been developed to transport material from one operation

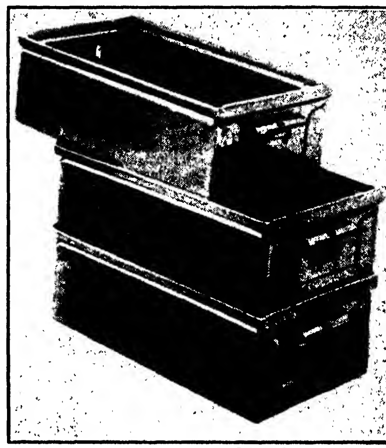
Courtesy, Kollsman Instrument Division, Square D Company

FIG. 14.12. Loading a tote box, which is just large enough to hold parts for an instrument. These tote boxes are used to get the parts to the operator on the assembly line.

to another (see Fig. 14.13). If these boxes are of proper size, they may be utilized for a standard number of each part. They are very sightly and durable and will nest one into the other when not in use, thus economizing in both floor space and labor of handling.

Standardization of the worker's chair, particularly of its height, has been given much study. In a factory where the work permits sitting, it will be found that, if the management has not provided chairs, the workmen will improvise seats out of old nail kegs and packing cases or make

themselves rough benches or stools. If the chairs are really an aid to the work, they should be furnished by the management and, as far as practicable, should be scientifically standardized and suited to the purpose for which they are to be used. In the telephone exchanges the importance of a proper chair has been, perhaps, most conclusively shown. Endeavors to improve and speed up service have resulted in close attention being given to the proper type of chair, and the adjustable-height, back-fitted chair that is used in all exchanges today was developed and has become an enormous aid in the handling of the great traffic passing over the large city switchboards.



Courtesy, Standard Pressed Steel Company

FIG. 14.13. Standard tote boxes.

The proper height of the work place and the chair depends largely on the nature of the work. As a general rule, on heavy work it is desirable to keep the lifting distance small. On the other hand, workers seated on ordinary chairs should not be required to bend too much; or, when the material handled is quite light, it may be profitable to allow the height of workbenches to be determined by the machine-bed level of near-by machines. Transfer trucks or tables on wheels of the same height can then be employed, and the bench hands provided with higher chairs. This arrangement has been found profitable in the finishing department of one large paper company and has expedited considerably certain operations that must be carried on both on machines and on benches.

One of the most satisfactory forms of commercial factory chairs is illustrated in Fig. 14.14. Chairs are available with broad saddle seats, adjustable legs, and close-fitting backs. Footrests may be needed, but these can be readily attached. Such equipment is of particular value when women are employed, as has been demonstrated through independent surveys made by the state departments of labor of New York and Pennsylvania and by the General Electric Company.

Tool standardization. Standardization of tools began with the experiments of Frederick W. Taylor at the Bethlehem Steel Company on the use of that common tool, the shovel. He showed that workmen, to be most effective in their work, must have a type of shovel peculiarly suited to the material which they are handling. His experiments indicated that a

shovel load under ordinary conditions could best be handled if it consisted of about 21 pounds. It therefore followed that, if the 21-pound load is to be secured in all cases, a shovel to be used in iron ore must be of a different size from one to be used for ordinary dirt, and a shovel to be used in moving coal must be smaller than one used for moving ashes.

Courtesy, Kollsman Instrument Division, Square D Company

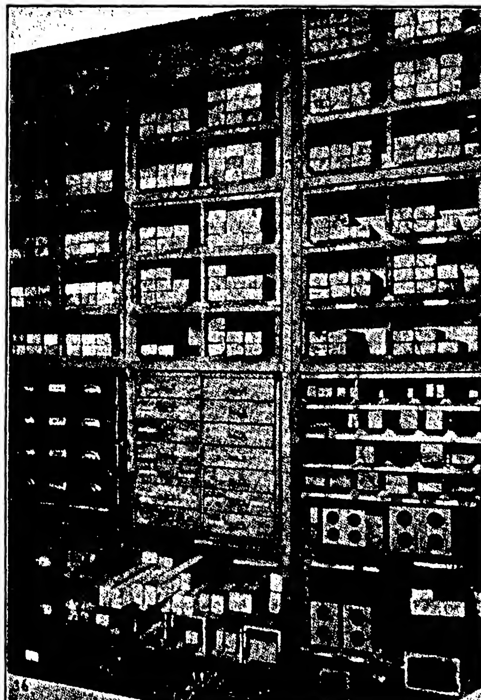
FIG. 14.14. A flexible work place. Individual pumps and equipment tables can be moved about at will. A single pump failure cannot halt the calibration. Note the back rest in the chair. Chairs of this type can be made with adjustable legs for persons of different heights.

Despite these experiments, to many people in industry a shovel is still a shovel. Frequently no particular attempt is made to see that the laboring gang is provided with different types of shovels, based on the material being worked on or on what is being done with it. Nevertheless, great strides have been made in numerous cases; particularly in the contracting business, much attention has been paid to the proper type of shovel.[3]

There are two general kinds of tools used on most jobs: first, the auxiliary tools used in the preparation of the job and its removal from the

[3] See D. J. Hauer, *Modern Management Applied to Construction,* McGraw-Hill Book Company.

machine, and, second, the actual tools used as a part of the machine in the performance of the operation. To see a high-priced machinist, who operates a machine tool on which the overhead machine rate is also high, spend fifteen minutes trying to get a bolt ready to hold his work on a machine is the best possible argument for the standardization of auxiliary tools



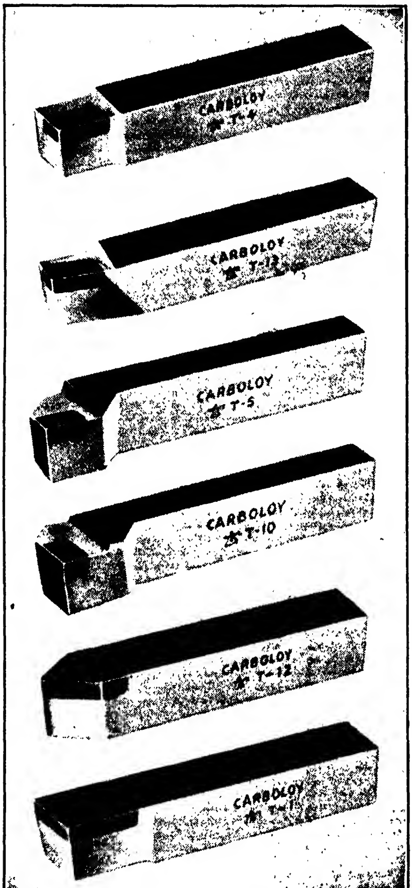
Courtesy, H. K. Hathaway

Fig. 14.15. Section of toolroom, showing standard woodblocks stored in standard bins.

and for the practice of storing and issuing them to the workman along with the material to be used, as is done with the operating tools. Figure 14.15 illustrates proper storage of such tools.

Fastening-tools in machine-shop work may be given much attention, not only to insure their being available when wanted, but also to see that they are of the right type and are in good condition. Frequently the preparation time for operations is almost as long as the time required for the operation itself. Therefore, proper auxiliary tools, which are usually inexpensive, become real money savers. All industries employ auxiliary tools, such as wrenches and screwdrivers, which can be readily standardized.

The operating tools in a machine shop consist of cutting tools that go into the machine and are changed with each type of job put into the machine. The composition of these cutting tools varies greatly and was completely revolutionized some years ago with the discovery of high-speed steel. New inventions are being perfected yearly, and it is not at all uncommon (and is highly desirable) to have a number of types of tool steel in stock in a shop. However, some steps must be taken to insure the use of tool steel of the proper grade on each job. To leave this selection to the workman is to leave it to guesswork. Many shops can still be found in which tools made from a dozen different qualities of steel are used side by side, frequently with little or no means of telling one from another. When one realizes that the cutting speed of the best air-hardened steel is, say, sixty feet per minute for a given depth of cut, feed, and quality of metal being cut, whereas with the same shaped tool made from the best carbon tool steel and under the same conditions the cutting speed is only twelve feet per minute, it becomes apparent how necessary is careful attention to the utilization of the right tool on the right job. Some of the special carboloy cutting tools are immeasurably more efficient than the best-known tool steels. Each type of cutting tool should be used where it is best suited to the work to be done. Carbon-steel tools are still used for many operations, as in accurate finish cuts.



Courtesy, Carboloy Company, Inc.

FIG. 14.16. Side view of lathe tools. Each tool is machine-ground for a specific purpose.

Tools are different not only in composition but also in the method of grinding. In the past the cutting edge was put on the tool largely by the workman at the job, who was accustomed to grind this edge entirely according to his own whims and prejudices. It can readily be seen that

to use a tool ground the wrong way is quite as bad a practice as to use a tool of the wrong composition. There is a particular shape of tool best adapted to each individual kind of work, and the tool should be ground at certain definite angles which a long series of carefully controlled experiments have shown to be best. It is obvious that, if all tools are to be ground to these correct angles, the responsibility for grinding them must be taken away from the men in the shop and placed in the hands of a man in the toolroom who has been provided with adequate tool-grinding equipment. Figure 14.16 shows the wide variations found in cutting tools used for the same job in one shop, in comparison with a tool for the job properly ground to conform to best practice.

CHAPTER 15

LIGHT AND POWER

Light

General considerations. Good lighting is necessary not only from the production standpoint, but also from the social standpoint. Since the modern industrial system forces many members of the community to use their eyes on close work, it becomes essential from the standpoint of community health that industrial lighting be adequate.

The modern factory building is so designed as to make maximum use of natural illumination, but this is not sufficient for multiple-shift operations or cloudy days. Artificial illumination has been developed to take care of these situations. Scientific research of large electrical manufacturers and of the Illuminating Engineering Society, together with the accumulated experience of plant superintendents, has produced artificial industrial light to meet the most exacting requirements of manufacturing.

Defective lighting. The results of the carefully controlled study of lighting conditions by the Hawthorne Plant of the Western Electric Company in Chicago indicated the difficulties encountered in ascribing increased production solely to one factor; there is little question, however, that defective lighting increases waste, places an unnecessary strain upon employees, and tends to decrease productivity.[1] In a pamphlet entitled "Light Conditioning—Industry's New Power," distributed by the Public Service Company of Northern Illinois, Table 15.1 is given to show the influence of improved lighting upon production.

Accidents are increased by improper lighting. "Many factors of poor illumination, such as glare, both direct from the lighting unit and reflected from the work, or dark shadows, hamper seeing and will cause after-images and excessive visual fatigue which are an important contributing cause of industrial accidents. Many accidents which are attributed to the individual's carelessness can actually be traced to difficulty of *seeing.*" [2]

[1] M. Luckiesh and Frank K. Moss, *The Science of Seeing,* D. Van Nostrand Company, New York, 1937, p. 157.

[2] See Illuminating Engineering Society, *Recommended Practice of Industrial Lighting,* p. 15. (This pamphlet is not dated; however, it refers to studies made by the Society as late as 1937.)

TABLE 15.1

EFFECTS OF ADEQUATE LIGHTING ON PRODUCTION

Company—Operation *	Old Level in Foot-candles †	New Level in Foot-candles †	Percentage of Production Increase
American Metal Works, Philadelphia, Pa., turret lathes	12	20	12
Decorative Lamp and Shade Co., Philadelphia, Pa., metal shop	3	15	18
Decorative Lamp and Shade Co., Philadelphia, Pa., workworking shop	5	25	21
Detroit Piston Ring Co., Detroit, Mich., grinding and machine work	1	14	26
Matell Mills, Philadelphia, Pa., splicing	5	28	8
Philadelphia Sweater Mills, Philadelphia, Pa., knitting	5	17	11
Realart Silk Hosiery, Philadelphia, Pa., knitting (*night*)	7	17	6
Reid Hosiery Co., Philadelphia, Pa., knitting	6	17	6
John Sidebotham, Philadelphia, Pa., loom	7	16	11
Timken Roller Bearing Co., Columbus, Ohio, inspecting	5	20	13

* Data originally taken from *G-E LaSalle Course on Lighting Salesmanship in the Fields of Selling, Seeing, Production*, Part 4, p. 124.

† A foot-candle is that unit of illumination intensity which is equal to the direct illumination given by a standard candle when placed one foot from the object illuminated.

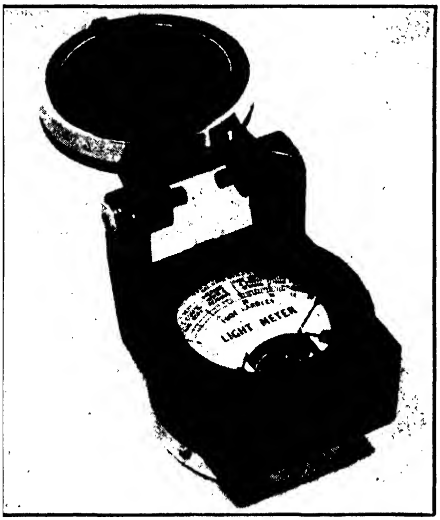
Advantages of adequate lighting. The Illuminating Engineering Society cites the following advantages of good industrial lighting:

1. Greater accuracy of workmanship, resulting in an improved quality of product with less spoilage and rework.
2. Increased production and decreased costs.
3. Better utilization of floor space.
4. More easily maintained cleanliness and neatness in the plant.
5. Greater ease of seeing, especially among older, experienced employees, thus making them more efficient.
6. Less eyestrain among employees.
7. Improved morale among employees, resulting in decreased labor turnover.
8. Fewer accidents.[3]

A uniform level of general lighting makes one part of the work place practically as desirable as another, thus enabling the industrial engineer

[3] Illuminating Engineering Society, *op. cit.*, p. 7.

to make most effective use of floor space. Good lighting has a direct effect on the cleanliness of the work place and its maintenance in general all-round good condition. As a rule, a dark shop is also a dirty shop; a light shop is usually a clean shop. Unquestionably an abundance of light in a factory has a desirable psychological effect upon the cheerfulness and well-being of the workers and thus tends to reduce labor turnover.



Courtesy, Westinghouse Electric and Manufacturing Company

FIG. 15.1. A foot-candle light meter. (The sensitive cell is in the top, which folds down when not in use.)

Requirements of artificial illumination. The minimum time that a normal industry uses artificial light during the year is twenty per cent of the total working hours. To this amount must be added that use which is constant when adequate daylight cannot reach a work place. The illumination provided artificially should (1) be of sufficient intensity for the particular operation being performed; (2) be diffused and not glaring, either directly or through reflection; (3) be uniform and not permit marked shadows. Absence of glare usually results in reduction or elimination of marked shadows. The uniformity of lighting desired depends somewhat upon its application. Diffusing of the light source is usually for the purpose of eliminating glare as far as possible.

Sufficiency of illumination. Illumination can be measured in terms of *foot-candles* by simple devices which record the extent of illumination at any given point (see Fig. 15.1). The output of electric light bulbs is expressed in terms of lumens. One lumen will light a surface of one square foot to an average intensity of one foot-candle. The number of lumens required to light a surface to any given illumination is the area of the surface in square feet multiplied by the average foot-candles of illumination desired. Table 15.2 lists the number of lumens produced by standard incandescent lamps.

The lamps of higher wattage are more efficient than those of lower wattage. In this connection it is also well to note that special bulb shapes

or finishes lower the efficiency of lamps. For instance, a 40-watt tubular lamp has an output 10 per cent lower than a standard lamp.[4]

TABLE 15.2

LUMEN OUTPUT OF INCANDESCENT LAMPS *

Wattage	Voltage	Lumen Output	Lumens per Watt
25	110, 115, 120	258	10.0
40		440	11.0
60		762	12.7
100		1530	15.3
200		3400	17.0
500		9800	19.6

* Source of data: *Handbook of Interior Design,* Industry Committee on Interior Wiring Design, 1937, p. 68.

The amount of illumination intensity required for any given operation is a matter of judgment. Where medium discrimination of detail is needed, the generally accepted amount of light is 10 to 20 foot-candles, with the tendency toward the upper limit rather than the lower. In considering the effect on the eyes of insufficient illumination, it is interesting to observe that the intensity of light on a clear summer day out of doors is from 100 foot-candles in the shade to many times this amount in places where there is no protection. Although intensities of 1000 foot-candles are impractical from an electrical and cost standpoint with artificial lighting, 50 to 100 foot-candles is needed if fine work requiring much concentration is to be carried on constantly without undue strain. In general, Table 15.3 will serve as a guide to the illumination required for various tasks.[5]

Work on light and dark materials falls into different ranges of intensity. Dark and rough surfaces absorb much more and reflect much less light than do smooth, light ones. Similarly, the amount of light required will be affected by the machinery that is used. Machinery painted black will absorb a great amount of light. Machinery painted gray will not cause undue reflection of light where it is not wanted and at the same time will not absorb nearly so much light.

[4] *Handbook of Interior Design,* Industry Committee on Interior Wiring Design, 1937, p. 39.

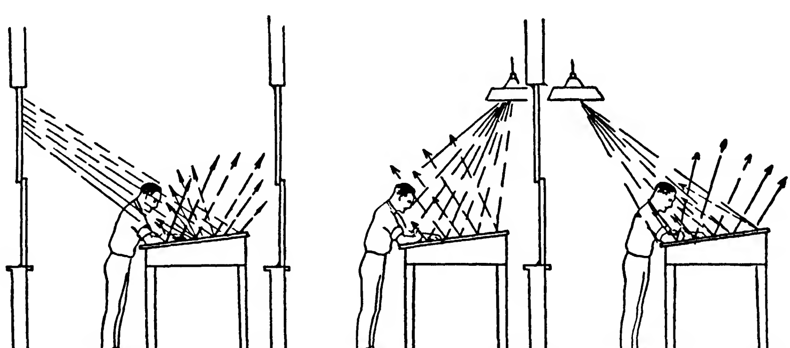
[5] For detailed information on industrial occupations, see *Handbook of Interior Wiring,* pp. 48–51; for office occupations, see W. C. Brown and Dean M. Warren, *Lighting for Seeing in the Office,* General Electric Company, Cleveland, 1936, pp. 12–13.

TABLE 15.3

LIGHT REQUIREMENTS FOR VARIOUS OCCUPATIONS

Nature of Occupation	Illumination in Foot-candles
Where discrimination of detail is not essential	2– 5
Handling material of a coarse nature, grinding clay products, rough sorting, coal and ash handling, foundry charging	
Where slight discrimination of detail is essential	5– 10
Rough machining, rough assembling, rough bench work, rough forging, grain milling.	
Where moderate discrimination of detail is essential	10– 20
Medium bench and machine work, fine moulding and core making, newspaper printing	
Where close discrimination of detail is essential	20– 30
Tool making, weaving, stitching and trimming	
Where very close discrimination of detail is essential	30– 50
Electrotyping, glass cutting, polishing and inspecting, drafting	
Where discrimination of minute detail is essential	50–100
Fine bench and machine work, fine inspecting, typesetting, engraving	

Although the quantity of light is very important, it should not be forgotten that this is only one factor in scientific illumination. Other factors to be considered are the distribution and quality of the light, contrasts, shadows, color, and glare.

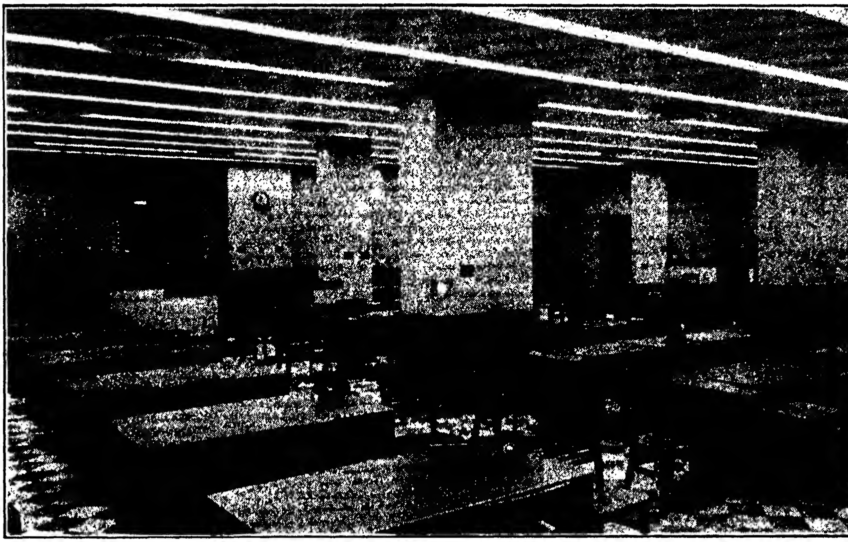


Courtesy, Edison Lamp Works

FIG. 15.2. Effect of changes in placing light outlets with proper reflectors.

Glare and reflectors. Glare is of two kinds; glare from the source of light, and glare of reflection from bright surfaces. Figure 15.2 indicates the manner in which the proper placing of light sources and proper type of reflector will eliminate the glare of reflection. Glare arises from improper diffusion, from the source of the light being intrinsically too

brilliant (more than about 2½ candles per square inch), and from the angle between the light, the work, and the eye being too small (less than about 30 degrees).

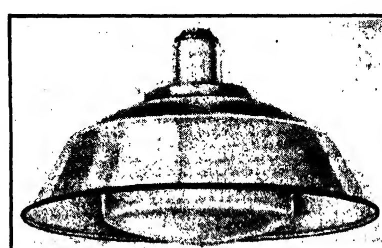


Courtesy, Libbey-Owens Ford Glass Company

FIG. 15.3. Ridge Flutex glass used in cove fluorescent-lighting equipment manufactured by the Pittsburgh Reflector Company.

Courtesy, Westinghouse Electric and Manufacturing Company

FIG. 15.4. RLM Reflector.



Courtesy, Westinghouse Electric and Manufacturing Company

FIG. 15.5. Glassteel Diffuser.

Indirect and semi-indirect reflectors are not as a rule suited to industrial use except in offices (Fig. 15.3). In general, industrial reflectors are of three types or variations of these types: (1) the RLM (Reflector and Lamp Manufacturer) (Fig. 15.4), (2) the Glassteel Diffuser (Fig. 15.5), and (3) the High-Mounting Reflector, designed for use in narrow interiors, such as craneways to be mounted at least 20 feet above the floor.

Types of electric lamps. The most popular type of electric light bulb is the tungsten-filament lamp which, when used in proper sizes and with appropriate reflectors, will provide adequate illumination for most purposes. Lamps with certain inert gases are generally more efficient than those in which the filament is enclosed by a vacuum. Daylight lamps and mercury-vapor lamps are also used for special purposes. In purchasing lamps, the cost per lumen produced over the efficient life of the

Courtesy, Libbey-Owens Ford Glass Company

FIG. 15.6. Adequate interior natural light. Frosted Aklo glass reduces sun glare.

bulb should be the governing consideration in determining the particular make to be bought.

Daylight bulbs are used where accurate color determination is needed. These bulbs are made of a special blue-green glass that absorbs a part of the reddish rays which are excessive in the usual tungsten-filament lamp. Since the glass in the daylight bulb absorbs approximately one third of the total light emitted by the filament, for efficiency reasons they should not be used except when absolutely necessary.

Special reflectors must be used under unusual conditions. Deep bowl reflectors must be used where a deep shielding angle is required to eliminate glare from the lamp filament, for instance where the mounting height is low, less than 8 feet above the floor. For all elevations up to 20 feet a white bowl bulb is best; above that height clear lamps may be used.

Uniform diffusion. The measure of effectiveness of a lighting system is not the brilliance of the source, but the ability of the worker to distinguish clearly and differentiate easily without eyestrain. Extreme brilliance improperly diffused only tends to tire the eyes and confuse the vision. Essential in this respect is the avoidance of irritating brilliancy or obscurity, the confusing shadows of obscurity being usually a result of too great brilliance. All portions of the room must be illuminated; there cannot be any dark spots which the eye will see and contrast with the brilliant spots where light falls.

Adequate diffusion makes possible ease of discernment of any object or portion of an object in any plane, horizontal or vertical (Fig. 15.6). Although large areas of dark shadow must be eliminated, entirely shadowless illumination is not to be desired. Shadowless objects are flat and not normal to the eye.

Shadows are influenced by the spacing and the hanging height of the lighting units. A broad, spreading cone of light, such as is produced by the RLM reflector, allows a lower mounting height than reflectors which concentrate light within narrow cones. The Glassteel Diffuser encloses the lamp in a white diffusing glass globe, and the porcelain enameled steel reflector has several slots through which some light is directed to the ceiling, so that there is less contrast between the ceiling and the work place.

Courtesy, Westinghouse Electric and Manufacturing Company

FIG. 15.7. A modern mercury-vapor lamp.

Mercury-vapor lamps. In operations where clear definition of surface is the outstanding requirement, mercury-vapor tube lamps have been used for many years.[6] Objections have been the high cost of operation in comparison to the tungsten-filament lamp, the size of the tube (50 inches long), and the ghastly appearance given to workers under these lights. Special transformers or reactors must be used in connection with the mercury-vapor lamp because of the fluctuation in voltage. A high-intensity mercury-vapor lamp has been developed that utilizes the standard screw base and is much shorter in length (see Fig. 15.7). This light bids fair to be an extremely valuable addition to industrial lighting equip-

[6] The mercury-vapor lamp emits fewer wavelengths of the visible spectrum than ordinary filament lamps. The eyes need not continually adjust to obtain the proper focus but can confine their efforts to focusing on the reduced number of wavelengths. This results in greater sharpness of vision and less fatigue, hence the clearer definition.

ment for foundries, spinning mills, small assembly work, composing rooms, and other places where close discrimination is needed.

Installations have been made combining the new mercury-vapor lamps with the ordinary filament lamps on a basis of equal lumen output from both. The result approximates the natural appearance of colors; however, there is still some color emphasis, particularly of the yellows.

Fluorescent lamps. The fluorescent Mazda lamp is an extension of the mercury-vapor principle or other types of "electric discharge" sources. Approximately half of the lamp wattage is radiated or accompanies the lumens. This characteristic of fluorescent lamps makes them ideal sources for the production of high levels of illumination at relatively low temperatures. This light can closely approximate daylight and also be so constructed as to give many different colors.

Methods of arranging artificial lighting sources. The methods for arranging lights in common use are: (1) general lighting, (2) group lighting, and (3) local lighting. The most frequent combination is that of general and local lighting.

General illumination is the method most used. Comparatively large units are placed near the ceiling, giving an illumination of approximately equal intensity throughout the whole workroom. This illumination is especially suited to miscellaneous work where a general distribution of light is more necessary than a local centralization of light in special places. An example of such conditions is shown in Fig. 13.16, p. 196. General lighting, properly spaced, gives an even diffusion of light. Illumination up to 50 foot-candles can be satisfactorily obtained from general lighting. For tasks requiring more than 50 foot-candles it is usually more economical to supplement the general lighting with local lighting. If 20-foot-candle general lighting is sufficient for most of the work in a workroom but a few operations require more, the additional light can more economically be provided also by local lighting.

Group lighting or, as it is often called, localized general lighting consists in lighting a particular group of machines or particular area by units which are so placed with reference to the work as to illuminate it from the best direction. This type of lighting is particularly suitable for large rooms with many machines of the same type performing such operations as spinning, weaving, and buffing.

Local lighting consists of the illumination of a single machine or portion of a machine with light which is specifically directed to the point at which illumination is most needed. Such lighting is used on workbenches, lathes, sewing machines, or any class of work where a light may be needed from a nearly horizontal direction or where a high intensity of illumina-

tion is required over a small area. Drop cords, formerly the standard method of getting local lighting to the desired point, have persisted in some plants until now. Fixtures such as the one illustrated in Fig. 15.8 are the approved methods of providing local illumination.

Maintenance of lighting installations. Maintenance of the lighting system should include a systematic plan for keeping the lamps and re-

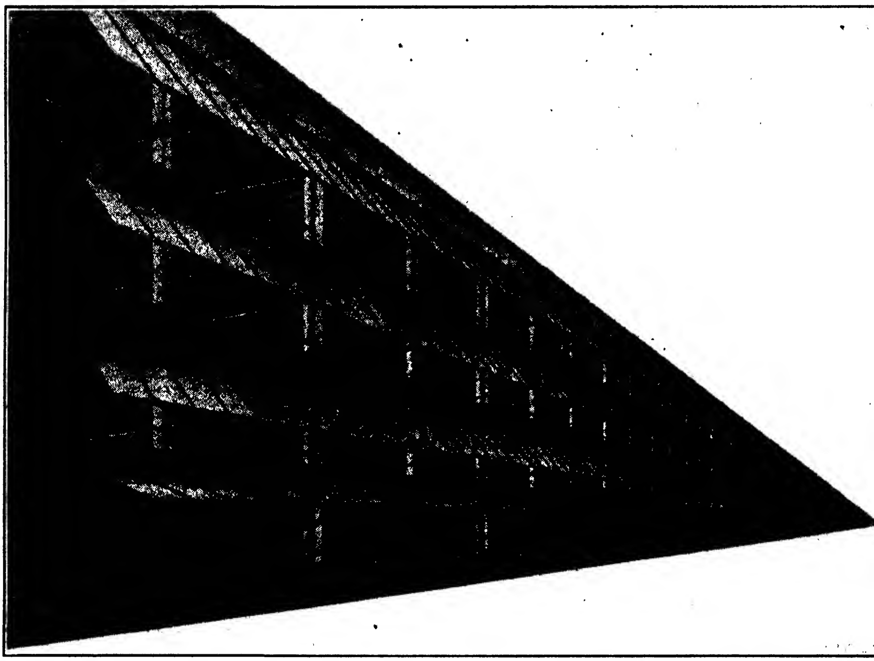
Courtesy, National Lamp Works

FIG. 15.8. Effective local illumination.

flectors in a clean and otherwise suitable state. When lamps deteriorate so that their lumen output is markedly below standard, they should be replaced immediately. Proper lighting maintenance includes painting walls and ceilings, cleaning lamps and reflectors, and changing bulbs when their lumen output drops markedly below standard. To maintain proper lighting requires accurate knowledge of the lumens at given points at regular intervals. This information may be secured by the use of the foot-candle meter (see Fig. 15.1). There is a general tendency to continue lamps in service far past the point where the installation of new lamps

would be profitable. The maintenance of the lighting system should be placed definitely in the hands of one member of the organization. The size and the structure of the organization will largely determine just where this responsibility should be placed.

Provision for adequate natural light. The provision for adequate natural lighting is directly related to the construction of the building.



Courtesy, Truscon Steel Company

FIG. 15.9. A unique provision for ventilation and lighting.

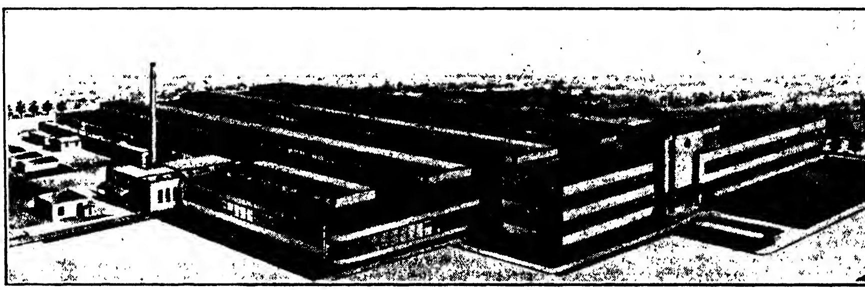
It is affected by such considerations as the nearness, character, and color of adjoining buildings, the height and width of the individual rooms, the provision of open courts in the layout of the plant, and the type of construction in so far as it affects the amount of window space that can be secured.

Natural light illuminates either by direct rays or by reflection from various surfaces outside or inside the factory building. Provision for natural lighting must take into account these reflections. The illumination given by daylight is general in that it tends to spread throughout the whole room, but its intensity is seriously decreased toward the center of the room unless light is admitted through windows in the roof.

Newer types of factory buildings have as nearly 100 per cent of their walls constructed of steel as is practicable. The development of steel

window sashes has greatly increased the amount of daylight that may be admitted. These windows may be opened individually or as a group (see Fig. 15.9).

The amount of natural light that reaches the interior of a factory workroom is dependent on the relationship between the height of the windows and the width of the room unless roof windows are provided to supplement the light from the side walls. If windows are on one side of the room, adequate light will be available for a distance twice the height of the windows. If windows are on two sides of a room, light will be available for a distance equal to about three times the height of the windows. Tables are available to show the amount of daylight available at different distances from windows with different heights. In multi-



Courtesy, Penn Electric Switch Company, Goshen, Ind.

FIG. 15.10. Modern factory building with monitor windows.

storied buildings the height of the windows on the lower floors is often made greater than on the upper floors to insure adequate illumination if surrounding structures cut off the light. As a general rule, it has been found that poor lighting will result if the ratio of floor space to window space is greater than six to one. In modern "daylight" factories the window space is from one-third to one-fifth as large as the floor space.

Glass bricks and tile are available for use in side-wall construction and have been used effectively for certain purposes. Although the cost is somewhat greater than standard constructions, they have genuine merit in structures where use is made of natural light in combination with mechanically controlled ventilation and temperatures.

Roof lighting. One-story factory buildings are often constructed to provide some roof lighting in addition to the light from the wall windows. These roof windows are of three types, namely, skylights, monitor roofs containing either vertical or sloping windows, and saw-tooth roofs containing both vertical and sloping windows. Skylights usually have the glass placed in nearly a horizontal position and consequently become dirty very easily. They therefore do not remain efficient transmitters

of light for long unless washed very often. Monitor roofs provide nearly ideal daylight conditions for factory interiors (see Fig. 15.10, showing the Penn Electric Switch Company). It is easy to keep monitor roof windows clean. They can be so placed as to give maximum light at the point midway between the side walls, where light from the wall windows is least. Wide monitors, at least one half the width of the building, are most efficient if single monitors are used. In any case the width of the monitor should be not less than twice the height of its windows, nor should the height be more than half its width. Increasing the height of a monitor increases the maximum illumination available, and sloping windows at times will increase the light at the point most needed. Saw-tooth roofs, with the sides containing the windows facing north to secure a minimum of direct light rays, are widely used in natural lighting (see Fig. 12.12, p. 179, showing the Poulsen and Nordon, Inc., plant). Narrowing the span of the saw-tooth or increasing the height of its windows increases the uniformity of light distribution.

TABLE 15.4

PERCENTAGE OF LIGHT REFLECTED FROM TYPICAL WALLS AND CEILINGS *

Surface	Class	Color	Percentage of Light Reflected
Paint	Light	White	81
Paint		Ivory	79
Paint		Cream	74
Caen stone		Cream	69
Paint	Medium	Buff	63
Paint		Light green	63
Paint		Light gray	58
Caen stone		Gray	56
Paint	Dark	Tan	48
Paint		Dark gray	26
Paint		Olive green	17
Paint		Light oak	32
Paint		Dark oak	13
Paint		Mahogany	8
Cement		Natural	25
Brick		Red	13

* Source of data: *Westinghouse Illumination Handbook,* Westinghouse Lamp Company, New York, 1934, p. 14.

The influence of paint upon adequacy of light. Interior painting is often neglected in factories long after the point has been reached where poor interior lighting calls for action. The percentage of light reflected from the walls and ceilings varies in general with the material and color, as shown in Table 15.4.

Although a high gloss on a painted wall reflects more light than a dull finish, its use is frequently unwise on walls which workmen face because of the glare in their eyes.

POWER

The management of an industrial enterprise is concerned with three primary requisites of factory power: (1) that there is adequate power at the machines to do the full amount of work scheduled for the factory; (2) that this power is secured in the most economical manner consistent with the long-run policy of the company; and (3) that the service is free from interruptions. The subject of factory power is too large for adequate technical treatment in this book, even if it properly had a place here. It is necessary only to outline the general principles governing the subject so that the manager may consider intelligently the engineer's report. There are certain phases of this problem, however, that can be passed upon only by the management, such as the decision to buy central-station power for all manufacturing requirements or for only peak requirements, to scrap an installation now in use and purchase central-station power, or to install a separate power-generating unit.

Sources of power. Factory power may be either generated within the plant or purchased from a utility. The former is usually referred to as isolated plant power, and the latter as central-station power. Management's decision regarding which type to use is important and should be preceded by a careful engineering study of all possible alternatives and their relative economies.

If only the electrical-power requirements of the factory are considered, this power may be supplied by:

1. Steam plants using either reciprocating engines or steam turbines.
2. Hydroelectric plants.
3. Gas-engine plants using producer, natural, blast-furnace, or coke-oven gas.
4. Internal-combustion (other than gas) engines employing fuel oil, gasoline, or other liquid fuel.

Central-station power. The central station, which can manufacture electrical energy in large quantities because of the refinements in apparatus which it uses but which are not usually feasible for the small isolated plant, can deliver current at its switchboard at a much lower cost

than many isolated plants. Even adding to the cost of current, as carefully calculated, the cost of distribution, the central station can often deliver current at the terminals of the customer's meter in a moderate-sized plant at a lower cost than the customer can make it for himself. This is also true in many cases where the power user must install a separate steam plant for heat in winter and for steam used in processes. Unless an isolated plant is of such size that it will pay to install apparatus approaching the central station in economy of operation, or unless the steam required for processing and heating is of such volume as to utilize the entire exhaust from the prime mover, central-station power will usually prove cheaper. As a general rule, if central-station power is available, it will seldom pay to generate power on the premises unless there is use for nearly all the exhaust steam. This rule is not to be followed too rigidly, for local rates and other considerations may be controlling factors in individual localities.

Combination of central-station and isolated-plant power. It is sometimes advantageous for the industrial plant to generate some power locally and purchase the rest. Utility rates often include a "maximum demand" rate based upon the peak value of power used, averaged over a specified period of time. It is to the advantage of the industry to keep the maximum power demand as low as possible. This may be accomplished by staggering the operation of the power-driven factory units. An isolated plant may be installed to supply part of the power during the periods of heaviest demand. In unusual cases where extreme continuity of service is required, special stand-by generators are installed to supply power in the event of interruption of central-station supply. Such generators can be used during peak periods to reduce the maximum demand on the utility system.

Reliability of service. Reliable service implies comparative freedom from interruptions in power. In a large city, where central-station power is distributed by an underground network, and especially where two or more central stations are connected to the network, the reliability of service is very high, often approaching or equaling 100 per cent over a period of years. On the other hand, plants located long distances from the central stations and depending on aerial transmission lines have suffered shutdowns for days because of weather conditions which put the transmission system out of operation. The relative location of the central station and the industrial plant should be considered in adopting central-station power.

Reliability of service in the isolated plant requires adequate reserve capacity for handling all probable contingencies. Careful operation and

reasonable attention to maintenance and repairs are essential to assure continuous service and long life of the equipment. Adequate fuel supply must be kept available. The equipment must be of sufficient size to supply the factory without overloading.

Fuel storage and service. The reserve supply of fuel is an important consideration in all power calculations. A plant so located that it is accessible to its source of fuel, as on a railroad line connecting directly with the coal mines or on a watercourse providing all-year transportation from the mines, need carry only a small reserve. If, however, it must depend on trucking its fuel or is in a district inaccessible to the mines or on railroads which may be interrupted in winter, the fuel reserve must be large. The interest on the investment in the fuel so carried is a proper charge to the cost of power, as is also the interest on the value of the real estate used for storage, together with the taxes on it.

Central stations usually carry adequate reserves of fuel and are so located as to receive and handle these reserves in the most economical manner. The cost of the fuel reserve is, of course, included in the rates charged for power. In choosing between isolated-plant or central-station power, the question of fuel supply and reserve must not be neglected.

Alternating current versus direct current. There are two types of power systems in general use: (1) alternating current, and (2) direct current. Most factories which have central-station power use alternating current. Some of the larger metropolitan areas still have direct-current systems, but they are gradually changing over to alternating current.

The advantage of alternating current is that the transmission voltage can be stepped up or stepped down at will by the use of a relatively inexpensive transformer, whereas direct-current power must be transmitted and used at the same voltage at which it is generated. Alternating-current power can therefore be transmitted over hundreds of miles at high voltages with very little loss. The greatest distance over which direct-current power can be economically transmitted in large amounts at the voltages ordinarily used for industrial purposes is approximately a thousand feet.

From the factory viewpoint direct-current motors are more flexible in operation than alternating-current motors of comparable cost. The speed of direct-current motors can be continuously variable over a wide range of speeds. The alternating-current induction motor, which is commonly used for industrial drives, has only a very limited range of speed variation. The speed can be made to vary in steps, that is, full speed, half speed, and quarter speed. In large-size motors, however, the auxiliary equipment for such variations is costly.

Load factor. Before considering whether central-station power is advisable in a particular case, it is well to have an understanding of the method by which rates are fixed for central-station power. The load on a power station varies from hour to hour, and the maximum load is much in excess of the average load. Nevertheless, the station equipment must be of sufficient capacity, and enough boilers must be kept under steam, to enable it to respond instantly to any demand that may be made upon it. Furthermore, the distribution system must have sufficient capacity to supply the maximum power demand. The *load factor* of a given industrial plant is the *ratio of the average power used to the peak power used.* The average and peak powers are averages over specified intervals of time.

Power factor. *"Power factor" is a term applied to the ratio of the power actually developed by an electric generator to the energy apparently developed.* With direct current the power developed can be ascertained by multiplying the reading of the voltmeter by the reading of the ammeter on the switchboard, the product being the power in the circuit in watts. With alternating current this product does not usually represent the power developed, and other means of ascertaining it must be utilized. With alternating current the energy in the circuit available for doing work is represented by Voltmeter reading × Ammeter reading × Power factor.

Obviously, the ideal condition would be to have all unity power-factor loads, since this would result in the minimum amount of current for a given amount of power. This condition is usually not possible, however, because induction motors, welders, and furnaces are often required in the operation of the factory. If an induction motor and a synchronous motor are connected to the same line, the induction-motor current will lag the voltage, whereas the synchronous-motor current can be made to lead the voltage. These effects will neutralize each other, and, if properly adjusted, the current supplied to the combined load will have unity power factor, and thus only useful current will be required of the generator and transmission system.

The disadvantages of low power factor are derived from the fact that it requires the generation and distribution system to supply an excessive amount of current for the power required. It is customary for utilities to include a low power-factor penalty clause in the rate structure. This provision is to compensate for the necessity of having larger equipment to supply the lower power-factor load. From the customers' viewpoint it is therefore sometimes desirable to install synchronous motors or other power-factor correcting equipment to maintain a high power factor on the system. Unfortunately, the applications of this type of equipment

are somewhat limited in the factory. Synchronous motors are constant-speed motors and can therefore be used only where constant-speed drives are required.

Electric rates. The cost of supplying consumers with power involves several items in addition to the actual cost of the current itself. Theoretically, each customer should bear his proportion of the cost of the distribution system from the central-station switchboard to his own meter terminals. Whether or not any current is used in a given month, the distribution system is there, and the charges on it must be met. Then, too, certain electrical losses occur in the distribution system and transformers, even though no current is used. These losses are a fair charge on the customer. In addition, there is the cost of keeping in service the surplus equipment to meet the peak-load demands for power.

The method of charging these costs to the consumer varies with different companies and in different parts of the country. To cover the cost of the distribution system some companies have a service charge, which is a flat rate irrespective of the amount of current used, plus an additional charge for the actual amount of electrical energy consumed. In addition, there may be a stand-by or readiness-to-serve charge to cover the cost of surplus equipment kept available for the customer's use.[7] This change is on a sliding scale and decreases as the quantity of current used increases. Then, for the actual amount of current used, there is a charge on a sliding scale, decreasing as the use of current increases.

Adequate power. Securing adequate power is an engineering problem from start to finish. The wisest management will be guided by the advice of engineers in its solution. A few hundred dollars spent for engineering services may easily result in the saving of several thousand dollars of operating cost annually.

Single-motor main drive. The single-motor main drive has little to commend it except low initial cost. It is largely a survival of the days when the entire factory was driven by a waterwheel or from the flywheel of a steam engine, before the electric motor permitted power to be distributed in any direction and in any quantity desired to any part of the plant (see Fig. 15.11). The disadvantages of this system are so many and so great that it should not be considered except under exceptional circumstances.

[7] The stand-by charge is not a part of all rate schedules. Some companies use only the "demand charge" to cover the costs that are independent of the number of kilowatt-hours used, and the "energy charge" to cover the costs that are proportional to the number of kilowatt-hours of energy used.

Group drive. In the group drive, instead of the jack-shafts being driven from a main line-shaft, each is driven by its own motor (see Fig. 15.12). Instead the line-shaft may be cut into sections, each driving a group of machines and each driven by its own motor. Or, the various machines of each class may be arranged in groups, and the shafting for each group driven by a single motor. This system, although of greater

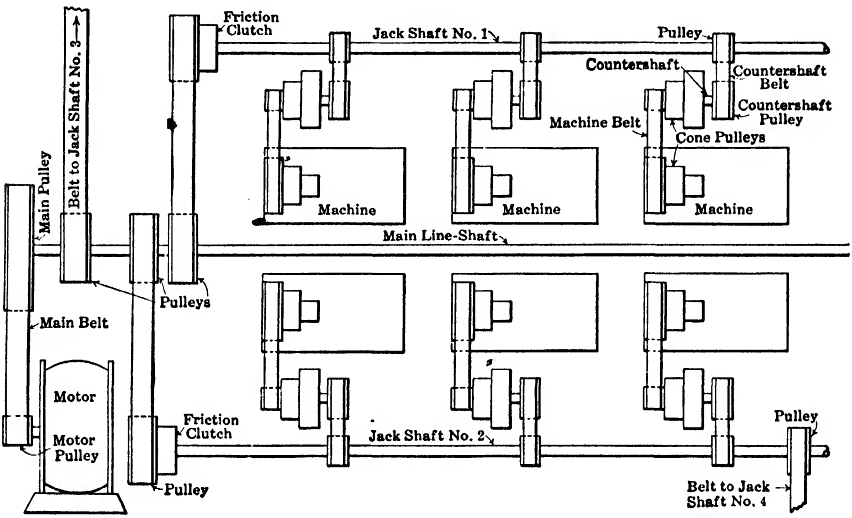


FIG. 15.11. Single-motor main drive.

initial cost than the single-motor main drive, is so much more flexible and has so many inherent advantages that it is more commonly used than the single-motor drive. With it the shafting friction losses are lower than with the single-motor drive, and any section of the shop can be run at any time without having to drive all the shafting. The machines can be arranged more conveniently for the work, without regard to the position of main line-shafts and without quarter-turn belts or mule-pulley stands to permit power to be taken off the main line-shaft at right angles to it. The motors can be better proportioned to the average load they will be called upon to carry, and the load factor and power factor, and hence the efficiency, of the system will be high.[8]

Individual-motor drive. In the individual-motor drive, each machine has its own motor, either mounted on it and driving through gears or silent chain, or mounted close by and driving through a belt (see Fig. 15.13). This system is the most flexible and permits machines to be

[8] This statement is made on the assumption that alternating current is being used.

arranged in the manner and position most suitable for the work without any regard for the source of power. It is highest in initial cost, and the total horsepower of motors to be installed is greater than in either of the other systems, since each machine must be equipped with a motor large

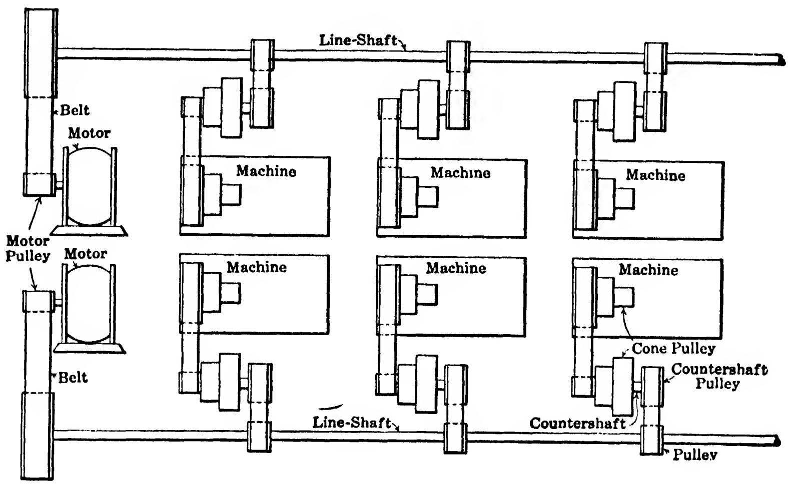


FIG. 15.12. Group drive.

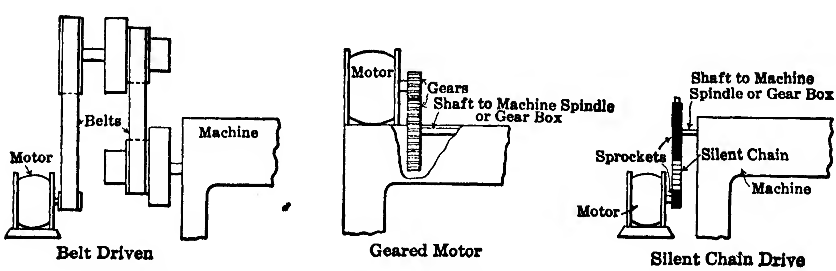


FIG. 15.13. Typical arrangements of individual-motor drive.

enough to pull the heaviest load that may be put on the machine and also because the efficiency of electric motors increases with their size. This fact will tend to make the load factor and also the power factor low if alternating current is used. In the group drive the motor usually needs to be only large enough for the average load, since it is quite unusual for every machine in a group to be under maximum load at the same time.

Combination group and individual-motor drive. Probably the most satisfactory system of driving, particularly in the metal-working industry and others where the demands for power on the several machines

are variable, is a combination of the group and individual-motor drives. In this system the machines requiring a relatively constant amount of power are driven in groups, whereas those requiring a large amount of power at irregular intervals are equipped with individual motors. This arrangement gives a very flexible system and smooth operation.

CHAPTER 16

AIR CONDITIONING

The importance of air conditioning. The presence of moisture in the air as a prerequisite for working certain materials properly has been recognized for centuries. The tobacco grower would not attempt to strip his tobacco when the air was dry because of the excessive breaking of the leaves. It was early discovered that the manufacture of cotton thread was simplified when the humidity of the air was fairly high. The first large-scale attempt to control the temperature of air as a matter of human comfort was made in the theaters, where the costs could be spread over a large number of persons.

Air conditioning in its broader sense is the control of the physical or chemical qualities of the air for a specific purpose. It includes the following factors taken alone or in any combination: (1) temperature, (2) humidity, (3) foreign substances, and (4) air flow.

Objectives of air conditioning. Air conditioning is usually undertaken to influence favorably the welfare and comfort of employees and customers, the materials and product, and the machinery, equipment, and manufacturing process. If these three major classifications are expanded, air conditioning may be said to seek to influence favorably men, materials, and processing as follows:

1. Employees and customers.
   - 1.1. To protect the health by removing poisonous and obnoxious gases and foreign particles, such as silica dust, lint, soot, and bacteria.
   - 1.2. To improve physical comfort by regulating the temperature and humidity and by reducing distracting noises, resulting in a favorable attitude or higher morale.
2. Materials.
   - 2.1. To decrease deterioration, as in meats, fruits, vegetables, and certain oils, fats, and chemicals.
   - 2.2. To increase workability, as in tobacco, textiles, and certain plastics.
   - 2.3. To improve the quality of products.
3. Equipment and processes.
   - 3.1. To meet the requirements of certain equipment that is sensitive to temperature changes, moisture, and foreign substances in the air.
   - 3.2. To reduce the maintenance cost of equipment.
   - 3.3. To meet the requirements of certain processes.

The individual's reaction to air conditioning. Man's reactions to the condition of the atmosphere in which he operates are both psychological and physiological, each somewhat influencing the other.[1] An individual may react unfavorably to the presence of certain odors in a room even though there is no detrimental physical action. Some people dislike an odor that others do not object to or perhaps even like. The addition of another, stronger odor which renders the first one unnoticeable but does not eliminate its cause often has the same effect upon the worker as removing the odor.

The comfort of an individual in still air is greatly influenced by his activity. The average-sized man, seated at rest in still air of approximately 70°F. with 50 per cent relative humidity, generates about 400 B.t.u. per hour. When this same man under similar conditions engages in light, moderately heavy, and heavy work, the British thermal units generated per hour rise to approximately 600, 800, and 1000 respectively. This heat is dissipated through direct contact with the air as *sensible heat* or through the evaporation of perspiration from the skin or the evaporation from the respiratory tract as *latent heat.*

The most important factors in poor industrial air conditions are improper temperature, improper humidity, or a combination of the two. Approximately 3000 cubic feet of air per person per hour, of the right temperature and humidity, should be provided, and the air can be changed from three to five times an hour to give this amount of air per person without any sensation of draft in the room. The proper temperature of air in a factory workroom depends upon the operation and upon the humidity. If the operation involves hard manual labor, it may be that in the winter months a temperature of 55°F. will be sufficient. The ordinary factory workroom can be kept at 65° and be comfortable if the humidity is correct. In the usual type of steam-heating system found in a factory, air which is 40° in temperature on the outside is brought in and heated to 70°. Naturally, this heating dries the air and makes it absorb moisture from anything in the room, particularly from the bodies of the workers. This gives rise to the feeling of discomfort and irritation which is frequently found in factory workrooms during the winter months. Air at 75° temperature and 20 per cent relative humidity does not feel so warm as air at 68° temperature and 50 per cent relative humidity, or 65° temperature and 65 per cent relative humidity. Of course, humidity cannot be continually increased.

[1] For an excellent discussion of this subject see F. C. Houghten, Director of the Research Laboratory, American Society of Heating and Ventilating Engineers, "Air Conditioning in Industry," American Management Association, *Production Series, No. 119.*

Much of the discomfort of summer temperatures is due to the high humidity, and 70 per cent humidity is probably the maximum which any air should be allowed to reach for normal working conditions.

TABLE 16.1

DESIRABLE INSIDE CONDITIONS IN SUMMER CORRESPONDING TO OUTSIDE TEMPERATURES * (OCCUPANCY 40 MINUTES)

Outside Dry-Bulb, Deg. F.	Inside Air Conditions			
	Effective Temperature, Deg. F.	Dry-Bulb, Deg. F.	Wet-Bulb, Deg. F.	Relative Humidity, Percentage
100	75 75	83 80	66 70	40 60
95	74 74	82 78	64 70	36 68
90	73 73	81 78	63 67	36 56
85	72 72	80 77	61 66	32 56
80	71 71	78 75	61 66	36 61

* Copyright, American Society of Heating and Ventilating Engineers. Abstracted by permission from Table 2, Chapter 3, *Heating, Ventilating, Air-Conditioning Guide,* 1939, p. 66.

For persons engaged in active, medium, or heavy muscular work this table is too high. The entire field of accurate control of air conditions is highly technical. Management should consult specialists in this field before spending large sums of money for an installation.

Table 16.1 gives a range of effective temperatures for individuals engaged in sedentary or light muscular activities. It should be kept in mind that there are individual differences within the same group as well as group differences among areas. For instance, the people of the Gulf Coast region will demand a comfort zone several degrees higher than the people of Milwaukee.[2]

[2] American Society of Heating and Ventilating Engineers, *Heating, Ventilating, Air-Conditioning Guide,* Vol. 17, p. 66, 1939.

The individual is often not so keenly sensitive to foreign substances in the air as he is to changes in temperature and humidity, yet these substances often are immeasurably more detrimental to his health. Certain occupational diseases originate from floating particles in the air. Silica is one of the most dangerous dusts.

Individual productivity is increased and fatigue is reduced by favorable working conditions. Proper temperature and relative humidity are vital factors of a comfortable work place. The retarding effects of unfavorable working conditions depend somewhat upon the characteristics of the workers and the nature of the work. It is not uncommon to find "white-collar" workers handicapped as much as manual workers, if not more, by high temperatures. This is especially true if the higher temperatures create conditions unfavorable for their work, such as perspiration interfering with drafting.

The need for air conditioning in processing. Certain processes are markedly influenced by the temperature and humidity of the air. A few industries having such processes are: spinning and weaving, baking, candy manufacturing, flour milling, precision-tool manufacturing of certain types, food storage, certain types of woodworking, the blast furnace, the tobacco industry, and the rubber industry.

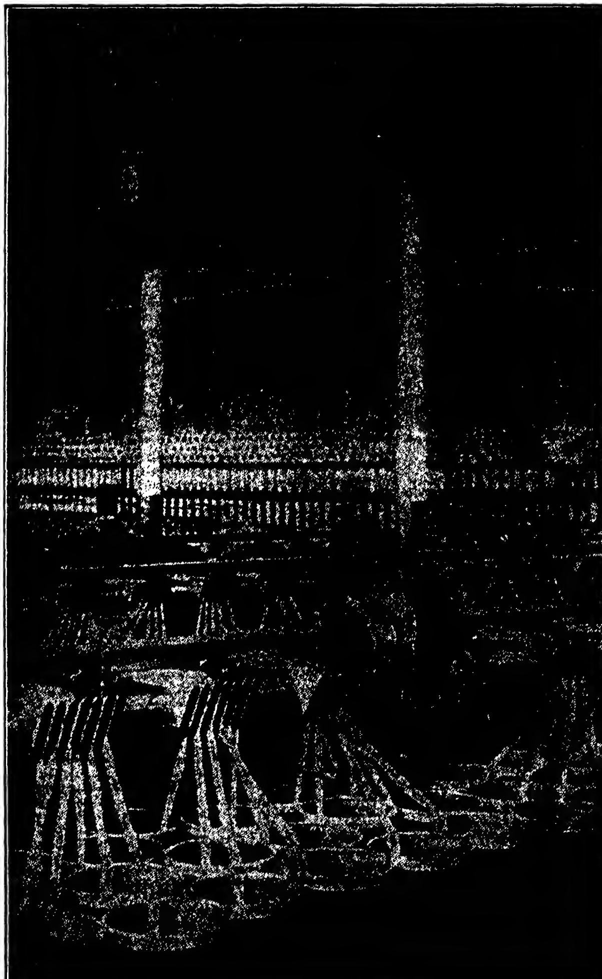
In textile mills, it is essential that moist air be present (see Fig. 16.1). This was the original reason why the textile mills of New England located near the foggy seacoast. If there is too little humidity in the atmosphere, the yarn becomes very dry in weaving and snaps, thus necessitating frequent stoppage of the loom to knot broken threads. If the humidity is too great, it affects the texture of the yarn, causing it to swell unevenly and making a poor grade of goods.

With the introduction of modern air conditioning, the textile industry can create its own climatic condition as far as manufacturing requirements are concerned. This fact has greatly influenced the migration of textile mills to the South.

Cabinet-making plants in which veneering is used also have less trouble with their raw material when working under proper temperature and humidity conditions. Not only is air conditioning a valuable aid to the working of wood, but also the application of the techniques of air conditioning has greatly hastened the drying of lumber. It is no longer necessary to stack it for long periods in the open air to allow it to "season." Kiln drying has largely replaced the air-drying process.

The Woodward Iron Company of Alabama has applied the principle of air conditioning to control the moisture content of the air used in their blast furnace. The air is preheated before being forced under pressure

into the furnace. This is a further step in standardizing their process of manufacture.



Courtesy, Parks-Cramer Company

FIG. 16.1. Cotton drawing, utilizing individual spray humidifiers.

The influence of building design on air conditioning. If a central air-conditioning system is planned, the air ducts are built into the walls and columns of the building as integral parts of the structure itself. In this way engineers avoid one of the objections to this system if it is installed after the building is constructed, when it is almost a necessity to place the air ducts overhead in the rooms (see Figs. 16.2 and 16.9).

Building construction also takes into consideration the requirements of natural ventilation. Natural ventilation is relied upon in most cases to carry off heat from the machines and to provide the fresh air required by the workers. Natural ventilation, in spite of the rapid strides made by controlled air conditioning, is still widely used in removing fumes and heat from furnaces and foundries (see Fig. 16.3). There is usually a prevailing wind in each locality, and the greatest natural flow of air into a building and out of it is secured when this wind blows at right angles to the wall having the greatest open-window area.

Courtesy, American Blower Company

Fig. 16.2. Distributing ducts for heating system in columns on machine-shop floor, Crown Cork & Seal Company, Baltimore, Md.

The windward side of monitor roofs should be kept closed, and the leeward side opened to get maximum natural ventilation. Under these conditions the wind will create suction, drawing the air from inside the building and out the open windows in the monitor (see Fig. 16.3). The size of the monitor openings and their height above the inlet openings are the major factors in determining the extent of the air flow.

Saw-tooth roofs are not well adapted to situations presenting severe ventilation problems, as the fact that they usually face the north may make ventilation difficult if the prevailing wind is from either the east or west. If the prevailing wind is from the south (an unusual condition), the saw-tooth roof is satisfactory.

Air-conditioning equipment. Steam pipes along the walls are still found in many of the older plants. They are wasteful of floor space, since it is difficult to place machines directly adjacent to the heating coils. Such installations always result in uneven temperatures, the windward side

of the building being cold, and the windows creating certain temperature problems because of the seepage of air usually occurring around them. Nevertheless the location of radiators under the windows is efficient from a heating standpoint if radiation is the sole method of distributing the heat. Much of the heat from radiators near the windows is likely to be expended in keeping outside cold air from forcing its way

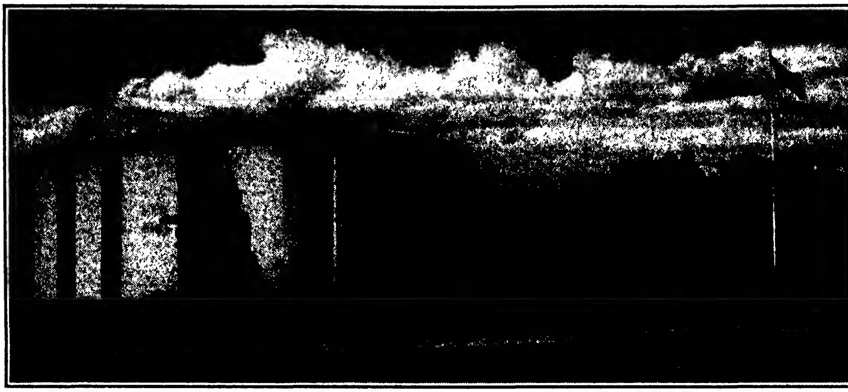
Courtesy, Detroit Steel Products Company

Fig. 16.3. Good ventilation in a foundry. (Monitor roof, lee windows open with windward side windows closed. Side wall windows open.)

in. Under such heating conditions humidity control is at best only a makeshift.

First, the long steam pipes along the walls gave way to the more efficient radiators, many of which were installed along the walls, as well as other places in the room for more effective heating. This development was followed by a type of central heating system, consisting of forcing air over heated coils and distributing the heated air to the work places. This system draws a fresh air supply into the building and propels it through the building by means of ducts, the outlets of which are properly spaced and so constructed as to prevent the seepage of cold air through the window openings. The disadvantage of this system is the presence

of the large ducts, usually overhead. They obstruct overhead lighting and at times are in the way of overhead cranes and conveyors. This system is admirably adapted to filtering the air before distributing it to



Courtesy, Industrial Tape Corporation

FIG. 16.4. Modern plant without windows.

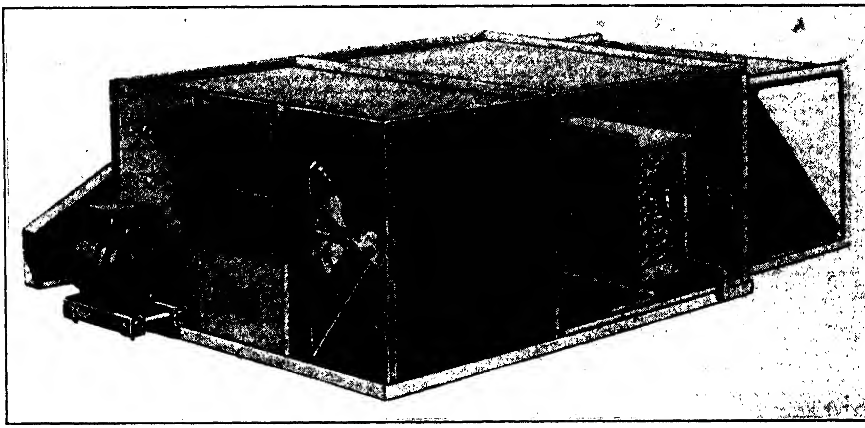
Courtesy, American Blower Corporation

FIG. 16.5. Unit heaters using steam for the heating medium.

the workrooms. It also lends itself to humidity control by adding the proper amount of moisture at a central control point.

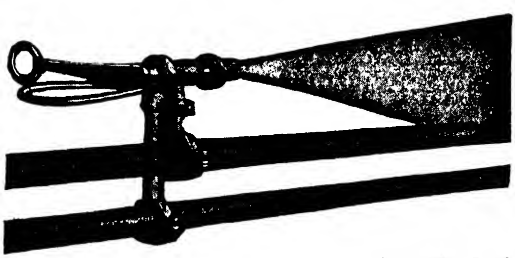
Many plants which have installed systems of this type have found it very difficult to prevail upon employees to keep the windows closed. In tact, some plants have had to go so far as to seal their windows shut, and

even then they frequently found in the summer time that employees removed these seals, although theoretically the air conditions within the building were much more satisfactory than those outside. Some manufacturers have solved this problem by constructing windowless plants (see Fig. 16.4).



Courtesy, Young Radiator Company, Racine, Wisconsin

FIG. 16.6. Cut-away view of an air-conditioning unit which provides year-round cooling, heating, humidifying, air filtering, air circulation, and ventilation.



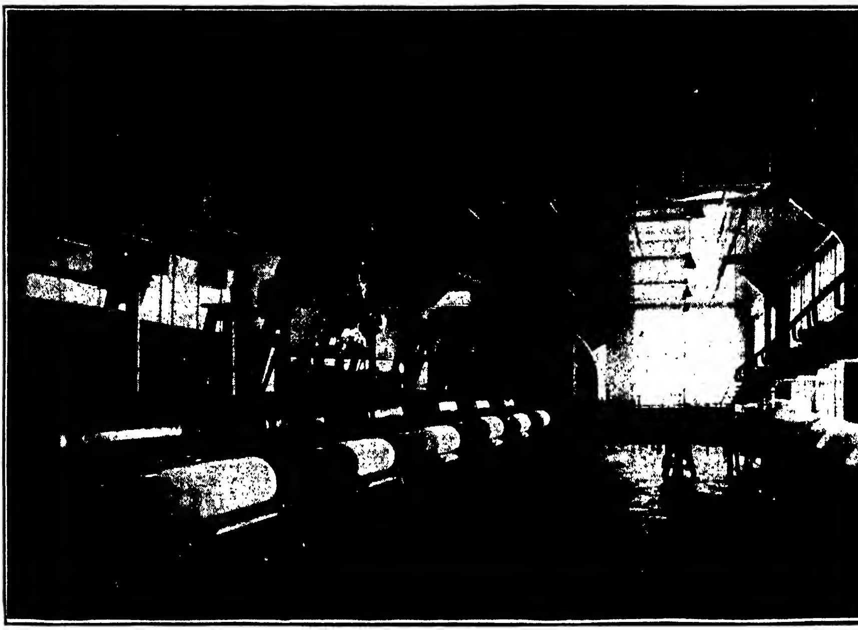
Courtesy, Parks-Cramer Company

FIG. 16.7. An atomizer humidifier, which relies on compressed air as the atomizing and distributing agency.

All the systems discussed are now found in various plants; however, the present tendency is toward the use of unit heaters placed where the heat can be most effectively distributed. These unit heaters (see Fig. 16.5) are constructed of coils, heated by steam, hot water, electricity, or gas, through which air is forced. The air may be brought in from the outside or from a central conditioning station, or it may be recirculated within the room. These units may be equipped with air filters, and some of them, for special installations, may be equipped to control humidity.

These heaters have the advantage of being located so as to circulate the air and thus avoid air stratification, particularly near the ceiling or the floor.

Humidity control. Admitting outside air in winter is the oldest method of reducing the temperature within a building. It is still used extensively. An alternative method is to reduce the amount of heat being fed



Courtesy, the Carrier Company

FIG. 16.8. Air conditioning in the carding room, Jackson Mills of Nashua Manufacturing Company, Nashua, N. H. (Central system.)

to the radiators or heating units. Admitting air from the outside during cold weather, either directly through the windows or through central heating stations, causes a drop in the relative humidity when this air is heated. Under such conditions satisfactory humidity can be obtained only by adding moisture to the air unless considerable moisture is given off from the manufacturing process; in this event, in the summer, moisture will have to be removed or the air changed rapidly. In radiator-heated rooms moisture may be added by placing humidifying saddles on the radiators, but these are not entirely satisfactory. The central heating system using ducts to distribute the air to the workrooms may have connected with it a moisture-control unit. Figure 16.6 illustrates a modern year-round central-heating and air-conditioning unit, which will heat

or cool, humidify or dehumidify, clean, and circulate the air. All the air or only a portion of it may be taken from the outside, depending upon conditions. It is usually more economical to recirculate a portion of the air.

Courtesy, the Carrier Company

Fig. 16.9. Process air conditioning in roving operation, Jackson Mills of Nashua Manufacturing Company, Nashua, N. H. (Central system.)

Where unit heating is used, but without a central system, it is possible to install unit air filters, humidifiers, and cooling units, either separately or as an integral part of the unit heaters. If it is not desired to condition all the air within a plant, the unit air conditioners are cheaper. The problem of adding moisture to the air is relatively simple, but removing it is considerably more difficult. When the temperature is lowered, the

relative humidity automatically is raised. One method of removing moisture is to lower the temperature so far that a good deal of the moisture is precipitated and the water may be drained off. This cold air then is mixed with the warm air in the room to obtain the desired tem-

Courtesy, American Blower Corporation

FIG. 16.10. Air-conditioning system, showing ducts supplying cool air to a foundry.

perature. Another method of removing the moisture is to use some chemical such as calcium chloride, which has the characteristic of absorbing moisture from the air. This is a simple method for a relatively small area but is not particularly suited for a large plant.

The separate humidifier (Fig. 16.7), which is located in the rooms of many textile mills, is still solving the problems of a large number of such plants satisfactorily. However, air-conditioning systems such as those just described can be of benefit to such textile plants, particularly in the

summer time, because the humidity can then be either increased or reduced at any given time. In the summer proper processing demands a decrease in the humidity rather than an increase (see Figs. 16.8 and 16.9). The problem of the bakery is solved by establishing a proof chamber with a temperature of approximately 120° and correct humidity, which is easily controlled. This chamber can be separated from the rooms where the workers are.

Courtesy, the Carrier Company

FIG. 16.11. Dust collection in asbestos carding.

Glass factories and other plants where workers are likely to suffer from intense heat can have the air conditions bettered by means of a ventilating system which includes cold-air ducts, such as those illustrated in Fig. 16.10.

Removal of dust or gas from materials worked in process may be made certain by a dust-collecting system, such as that illustrated in Fig. 16.11, 16.12, and 16.13.

Removing foreign substances from the air. Foreign matter may be wholly or partly removed from the air by the following methods:

1. Washing—forcing the air through a spray of water. This method will remove certain large particles and some gases that are soluble in water.
2. Mechanical filtration—passing the air through the filters, which collect particles above a certain size.
3. Electrostatic precipitation.

Washing air has the advantages of increasing the humidity and lowering the temperature. Under certain conditions it may be necessary to dehumidify to get the proper humidity. For certain conditions this system is entirely satisfactory.

Courtesy, Torit Manufacturing Company, St. Paul

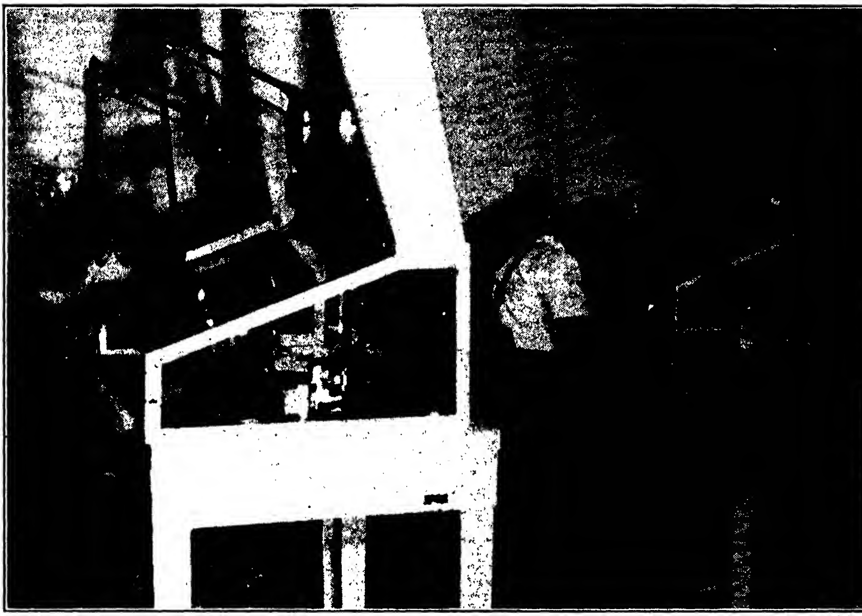
FIG. 16.12. Torit dust collector for an individual machine.

Mechanical filters are all classified under the following headings: throw-aways, those that are used until they become partially clogged and are then discarded; permanent type, those that may be removed and cleaned; replacement fabric type, those that may be removed and have new fabric inserted; and the continuous oil type (automatic).

Electrostatic precipitation has been successfully used for years in smokestacks of boilers, smelters, and cement mills.[3] The same principle has been adapted to cleaning air for use in the work place, hospitals, hotels,

[3] See "New Developments in Solving Industry's Problems of Dust and Air Pollution," George F. Begoon, American Management Association, *Production Series No. 119.*

and other institutions. The Westinghouse Electric Corporation has developed an air-cleaning mechanism known as the Precipitron, which cleans air for commercial purposes to a degree far in excess of anything



Courtesy, Air Technical Service Command, Dayton, Ohio

Fig. 16.13. Precaution against radium poison for workers using luminous paint includes a lead-bottom work cabinet with glass top and sides and an exhaust at the rate of 100 cubic feet per minute to draw off the radon gas.

that has been available. The Precipitron is of especial value to hospitals and homes where pollens annoy hay-fever victims. The initial cost of the mechanism, however, is considerably greater than that of mechanical filters and washing systems.

CHAPTER 17

THE MAINTENANCE DEPARTMENT

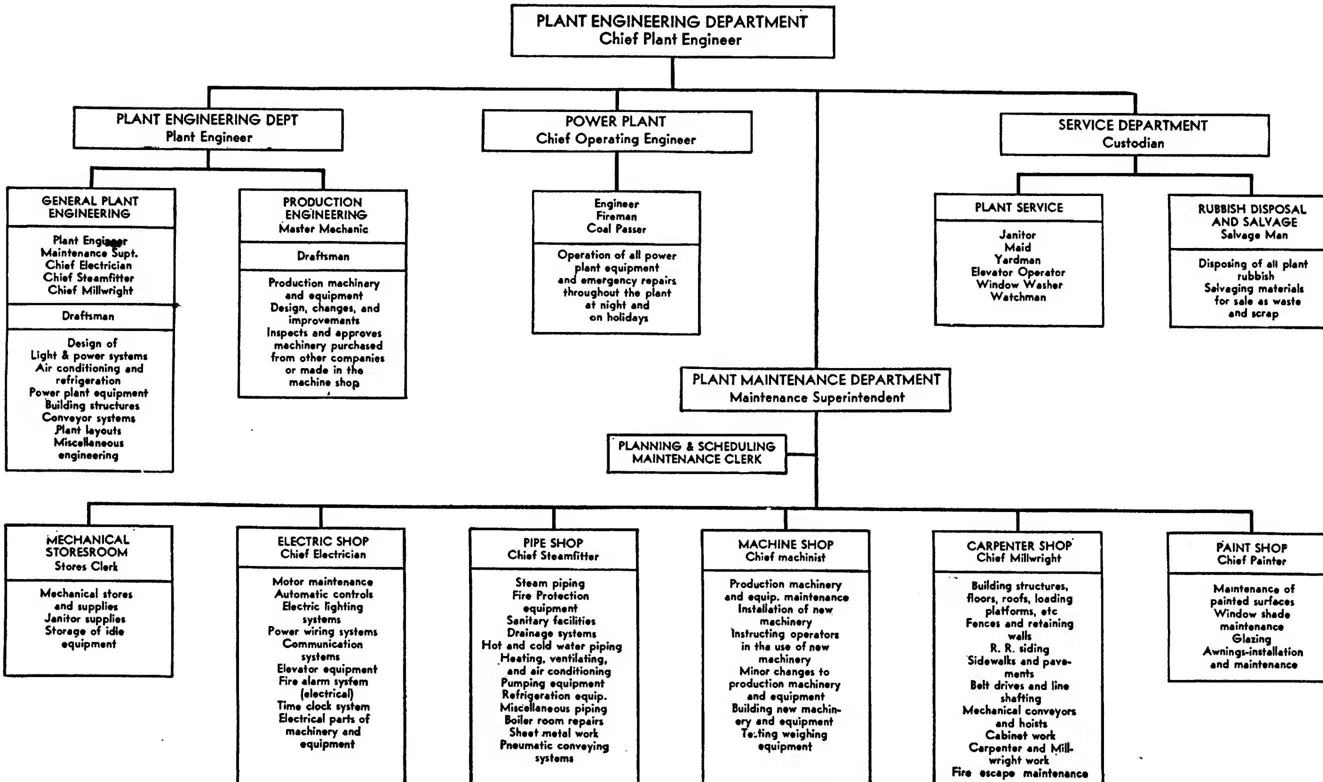
The place of the maintenance department in the organization. The maintenance department is primarily a service department, although in some companies it also has charge of new construction. In most instances the man in charge of maintenance reports to the works manager directly or through other division heads. A few of the combinations showing the line of authority and responsibility of the superintendent or head of the maintenance department are as follows:

1. Through plant superintendent to works manager.
2. Through production-control superintendent to works manager.
3. Through master mechanic to works manager.
4. Through superintendent of nonproductive labor to works manager.
5. Through plant engineer to works manager.
6. Through plant engineer, industrial engineer to works manager.
7. Through plant engineer, chief engineer to works manager.

If there is no works manager, the combination reports to the person who exercises the function of works manager or in a few cases to a vice-president in charge of buildings and equipment, who answers to the president.

Figure 17.1 illustrates the organization of the maintenance department in the Chicago plant of the Victor Adding Machine Company. In this particular organization all requests for maintenance work are routed through the industrial-engineering department. The industrial-engineering department issues all orders to the maintenance department in much the same manner that production orders are issued to the manufacturing department. This procedure makes use of the principle of specialization, separating the "planning" from the "doing" function. "From an over-all viewpoint it has been roughly estimated that the proper employment of highest skills has resulted in (1) saving one-third of available productive maintenance time; (2) increasing by one-half worker efficiency in the maintenance department." [1]

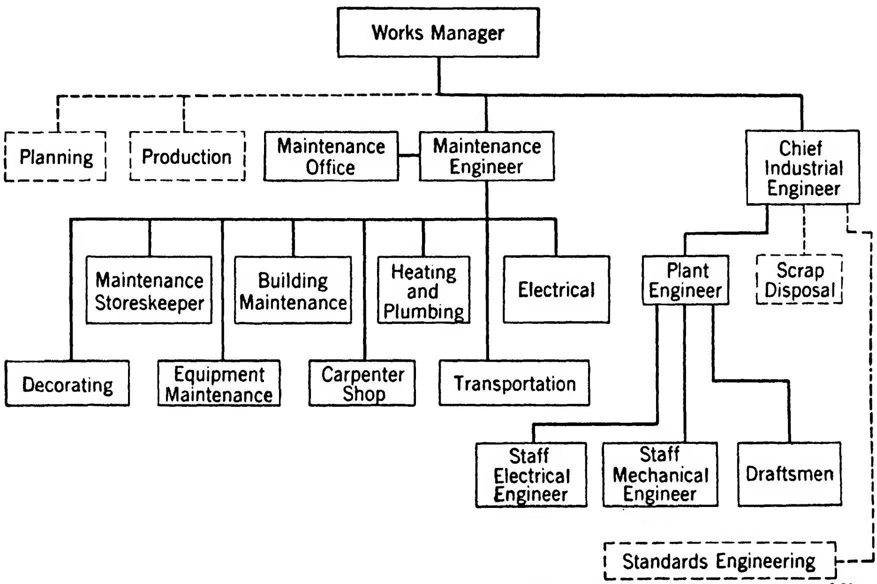
[1] See R. F. Bartlett, "Production Methods Applied to Plant Maintenance," *Factory Management and Maintenance*, Vol. 103, No. 9, p. 133.



Courtesy, Prentice-Hall, Inc., from W. R. Spriegel and Ernest C. Davies, "Principles of Business Organization" (1946)

FIG. 17.2. Plant engineering department, showing the position of the maintenance department.

A second organization structure for the maintenance department is shown in Fig. 17.2. In this organization the maintenance department is part of a larger division specializing in construction, plant layout, power generation, plant service and protection, salvage, and repairs and maintenance of plant and equipment. Figure 17.3 is similar to 17.2 but differs in certain details. Both Figures 17.1 and 17.2 show a high degree of

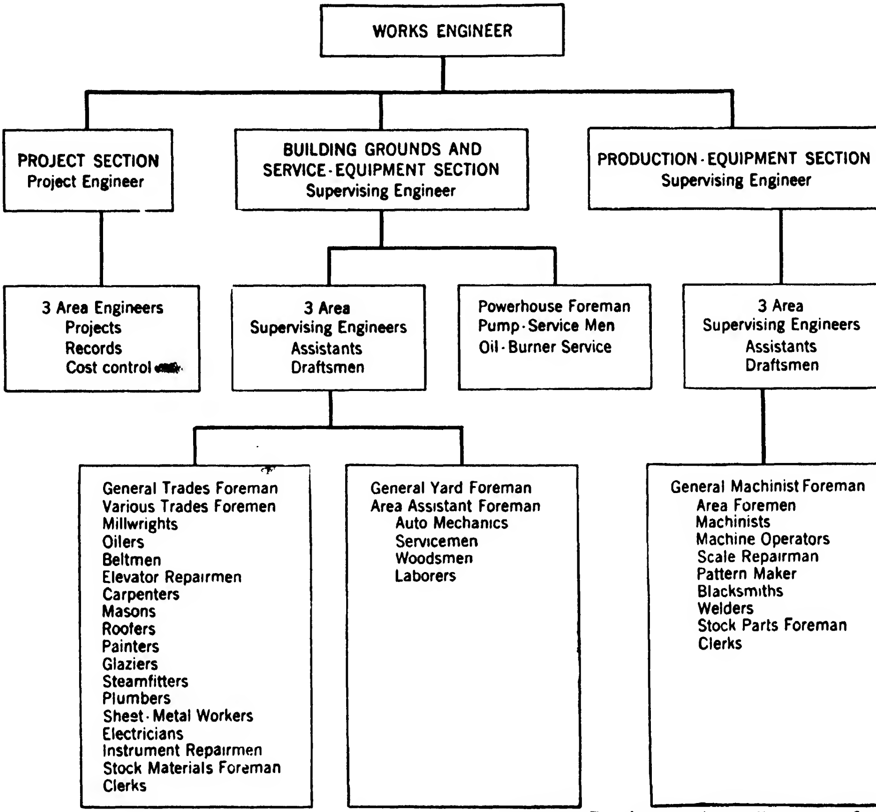


Courtesy, R. F. Bartlett, Plant Engineer, Victor Adding Machine Company, Chicago, Ill.

FIG. 17.1. Organization chart of the Victor Adding Machine Company maintenance department.

specialization. In many plants transportation is not under or associated with the maintenance department or plant engineer except for the repair of equipment. In other organizations all internal and external transportation comes under the plant engineer. The so-called "yard gang" of common laborers is frequently under the maintenance department.

Figure 17.4 illustrates a simple maintenance department in a medium-sized plant. In this case each of the major skills is supervised by a foreman who reports to the general superintendent of maintenance. The same organization structure is frequently used in smaller enterprises, with the foremen being working bosses rather than supervisors only. In this event the title given to the man heading the maintenance function is usually foreman rather than superintendent or master mechanic.



Courtesy, Remington Arms Company, Inc.

FIG. 17.3. Maintenance organization.

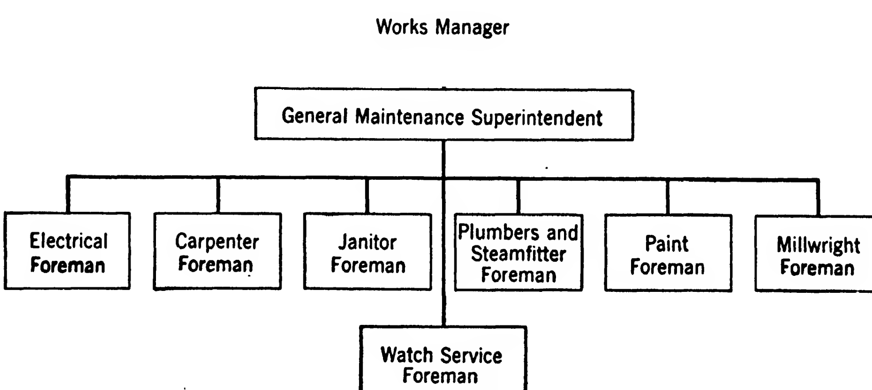


FIG. 17.4. Maintenance department of a medium-sized plant.

The importance of the maintenance function. In every enterprise provision must be made for work of the nature performed by the maintenance department. In a few instances in the old days each foreman took care of his repairs and janitor work. This system had the advantage of causing him to be more conscious of the proper use of machinery but in general was inefficient. Today practically every enterprise of any size—hotel, store, school, factory, or utility—has its maintenance department. The smooth functioning of the entire operating department is vitally dependent upon the effective operation of the men behind the scenes, the maintenance workers. Breakdown of an elevator, conveyor, lighting system, refrigeration system, water system, or of any other vital source of power or other aids usually causes cessation of operations or at least great inconvenience. Preventive maintenance is more efficient than remedial maintenance. In other words, inspection before a breakdown enables the maintenance engineer to plan repairs and schedule them when the plant is inactive at nights or over week ends, thus preventing a breakdown and disturbance of operations.

The function of the plant engineering and maintenance department. An inspection of Figs. 17.1 and 17.2 reveals the general nature of the work performed by the maintenance department. In actual operations the plant engineer and the maintenance department carry on the following activities:

1. Keep the buildings and grounds in clean, sanitary condition.
2. Make emergency repairs.
3. Make routine repairs that are not of an emergency nature.
4. Inspect the buildings, equipment, and machines to detect misuse or needed repairs.
5. Schedule repairs and renewals in such a manner as to make maximum use of the available manpower and to minimize the disturbance to operations.
6. Keep records of the various machines and equipment as a guide to the proper use and the selection of new equipment for a given purpose.
7. Supervise construction work performed by an outside contractor or do the actual construction with company men. (It is often cheaper to have outside specialists do major construction work or even major repairs than to do it with the regular maintenance crew.
8. Sharpen production tools. (This function is frequently carried out by someone in the tool crib who operates under the manufacturing department or the production-control department.)
9. Maintain cost records that are used by the accounting department and by management.

Inspection of buildings and equipment. Inspection in maintenance is both remedial and preventive. After machinery breaks down or some other damage is done, inspection is necessary to discover the cause and

make the needed repair. When a pin is sheared and a conveyor stops running, it is not enough to replace the worn pin with one which may be able to carry the load. Somewhere else in the system some other item may be out of line, throwing upon the entire system an unnecessary drag which needs to be adjusted. Inspection is also an aid in estimating the time required to make the repairs.

Preventive inspection is designed to reduce hazards and avoid losses that arise from not making repairs before damage is done. For preventive inspection to be of maximum value it must be systematic, that is, scheduled according to the needs of a given situation. For instance, an elevator cable does not need to be inspected so often as the exhaust system carrying off the fumes from a duco spray booth. In order for inspection to be performed according to the reasonable need of each situation an inspection schedule should be established and carefully followed. Figures 17.5 and 17.6 show two maintenance schedules used by the Victor Adding Machine Company. Figure 17.5 shows a schedule for cleaning, overhauling, and functional checking. Figure 17.6 gives a lighting-maintenance schedule.

Costs of maintenance. Maintenance costs are by no means uniform for different industries, for companies in the same industry, or within the same company during different periods. There must be some basis of comparison, or the figures are meaningless. In the excellent article published in *Factory Management and Maintenance* (see Table 17.1) net sales were used as the basis of comparison. This is probably the best basis for comparing different industries. Costs vary from year to year in the same company because of economic conditions both within and without the plant. In extremely busy periods, which occasionally last longer than a year, such as during wartime or while there is intense consumer demand for a particular product, repairs may be postponed as long as possible. During very slack periods funds may be conserved by postponing repairs, particularly when surplus machines are available. Most repairs are made during normal operating conditions or a period of rising production.

Sound management procedures call for a maintenance budget somewhat related to the volume of operations. When conditions demand the postponement of repairs, there accumulates a deferred expense that may become greater with delay. If maintenance of lights is deferred, the cost of current operations may be materially increased.

Operating the maintenance department. Because of the very nature of most maintenance work close supervision is somewhat difficult. Maintenance men usually work in small groups or alone. Unless someone in

TABLE 17.1

THE COST OF MAINTENANCE IN TWENTY-FIVE INDUSTRIES *

Industry †	Number of Companies		Maintenance and Repair Costs Percentage of Net Sales					
			1942			1943		
	1942	1943	Individual Company		Industry Average	Individual Company		Industry Average
			High	Low		High	Low	
Agricultural machinery and tractors	10	10	4.1	1.2	3.2	4.6	1.0	3.1
Apparel and related finished products (shirts, ties, hats, underwear)	17	16	1.9	0.1	1.0	2.8	0.2	1.1
Automobiles	10	10	6.5	1.1	6.9	5.0	1.3	6.3
Bread and cake	7	8	4.0	1.8	2.7	4.5	1.7	2.7
Building equipment (stoves, furnaces, pipefittings, locks)	22	23	5.7	0.3	2.7	5.7	0.2	2.8
Cigarettes	7	6	0.6	0 ‡	0.2	0.5	0 ‡	0.2
Cigars	8	8	1.8	0.2	0.8	2.1	0.5	0.8
Clocks and watches	5	5	3.1	0.9	2.1	5.0	1.0	2.7
Dairy products	8	9	2.6	0.8	2.1	2.6	0.8	2.0
Drugs and medicines	15	15	3.2	0.5	1.0	2.7	0.5	1.1
Electrical household appliances and related products	17	18	6.1	0.7	2.7	5.1	0.5	2.6
Firearms	3	3	2.1	0.5	2.0	2.2	0.1	2.2
Grocery specialties and miscellaneous food products	14	14	3.1	0 §	1.3	3.3	0 ‖	1.5
Hosiery	12	12	2.8	0.9	1.6	2.9	0.6	1.7
Iron and steel foundry products	9	9	8.5 ¶	2.8	6.1	8.8 ¶	2.4	6.6
Meat packing and allied products	13	14	2.2	0.2	0.9	1.1	0.2	0.9
Metal-working machinery (machine tools, saws, drills, presses)	29	29	6.5	0.1	2.2	7.0	0.2	2.2
Paints and varnishes	9	9	1.4	0.4	1.1	1.6	0.3	1.2
Paper and allied products	47	46	9.6	0.2	4.7	9.2	0.2	4.5
Pig iron	4	4	9.5	4.9	6.7	9.9	5.9	7.7
Newspapers and periodicals	9	8	4.2	0.1	1.4	1.7	0.1	1.0
Radio and radio equipment	17	19	5.8	0.3	2.2	7.0	0.1	1.9
Screw machine products	3	3	4.9	1.4	2.8	3.7	1.0	2.2
Shoes	14	13	2.0	0.3	1.2	2.0	0.4	1.1
Textile fabrics	12	14	4.3	0.4	2.0	3.4	0.4	1.8
Tires and other rubber products	16	16	3.7	0.7	2.3	4.1	1.1	2.2

* This table was compiled by permission from "The Cost of Maintenance in Seventy-five Industries," *Factory Management and Maintenance*, October, 1945.

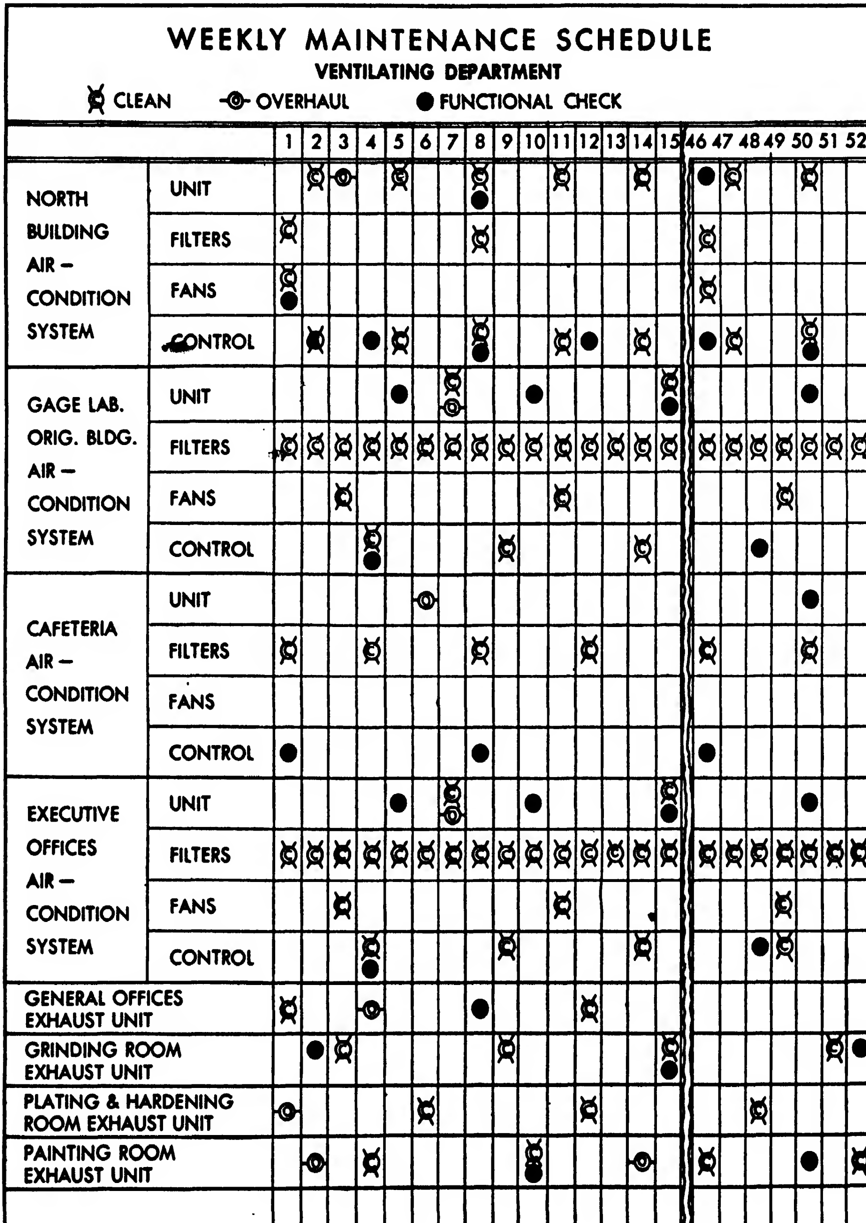
† The survey includes only those companies which have securities listed and registered on national securities exchanges under the Securities Exchange Act of 1934, or which are required to file annual reports as registrants under the Securities Act of 1933. Only manufacturing companies are considered here.

‡ Reasons for this figure were not given. The next lowest figure was 0.2 per cent.

§ Reasons for this figure were not given. The next lowest figure was 0.3 per cent.

‖ Reasons for this figure were not given. The next lowest figure was 0.4 per cent.

¶ Includes repairs, replacements, and additions to patterns and flasks.



Courtesy, Victor Adding Machine Company and "Factory Management and Maintenance"

FIG. 17.5. Schedule for the maintenance of a ventilating system.

a responsible position carefully inspects the work and estimates the time required to do it, the worker may take twice as long as needed without anyone knowing the difference. There is probably no department in most factories where the efficiency is lower than in the maintenance department. Relatively few standards have been set for this kind of work. Most supervisors have themselves been tradesmen in their respective

MAINTENANCE SCHEDULE
ENGINEERING DEPARTMENT
Cleaning and Relamping Periods

FLOOR											
Jan.	Feb.	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.
C&R		C		C&R		C		C&R		C	
C&R		C		C&R		C		C&R		C	
C&R		C		C&R		C		C&R		C	
C&R		C		C		C&R		C		C	
C&R		C		C		C&R		C		C	
C&R		C		C		C&R		C		C	
C&R			C			C&R			C		
C&R			C			C&R			C		
C&R			C			C&R			C		
FLOOR											
C&R			C			C&R			C		
C&R			C			C&R			C		
C&R			C			C&R			C		
C&R			C			C&R			C		

Courtesy, Victor Adding Machine Company and "Factory Management and Maintenance"

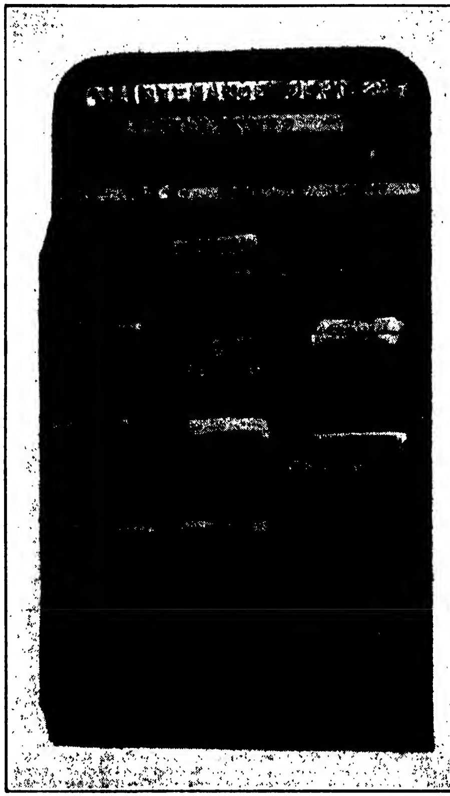
Fig. 17.6. Cleaning schedule for lamps.

fields and in reality have no special desire to use scientific techniques that are well established in other phases of manufacturing. Most maintenance men are paid on a flat hourly basis and have no particular incentive to do more work than the average, which is not what the average man can do but what he does in the absence of close supervision and established standards.

Probably the most effective method to increase the operating efficiency among maintenance workers is to have each job estimated by a skilled estimator and to pay the workman his regular day rate, with a portion of the time saved as a bonus for finishing the job in less than the required time.[2] Such a program entails additional expense for supervision, but the

[2] See "Wage Incentives Encourage Better Housekeeping," *Factory Management and Maintenance*, Vol. 103, No. 12, p. 136, for a computation of incentive payment for janitors.

possibility for savings is great. Each job is scheduled like a production job except for emergencies. Even in an emergency in most cases an estimate can be made by the man in charge of maintenance. Figure 17.7 illustrates a simple control mechanism for scheduling maintenance work.



Courtesy, E. A. Munson, Plant Engineer, Gould and Eberhardt, and "Factory Management and Maintenance"

FIG. 17.7. Schedule order rack for maintenance work.

Careful supervision and inspection are necessary when the workers are paid on an incentive system.

Maintenance records. In addition to schedules for regular inspection and preventive repairs, several other records are kept by many maintenance departments. An individual record of each machine of any importance is a valuable aid in estimating the relative effectiveness of various machines. This record usually gives the date of purchase of the machine and the dates of all major repairs, as well as the nature of these repairs. This department also frequently keeps a detailed inventory, as

MAINTENANCE-DEPARTMENT WORK AUTHORIZATION

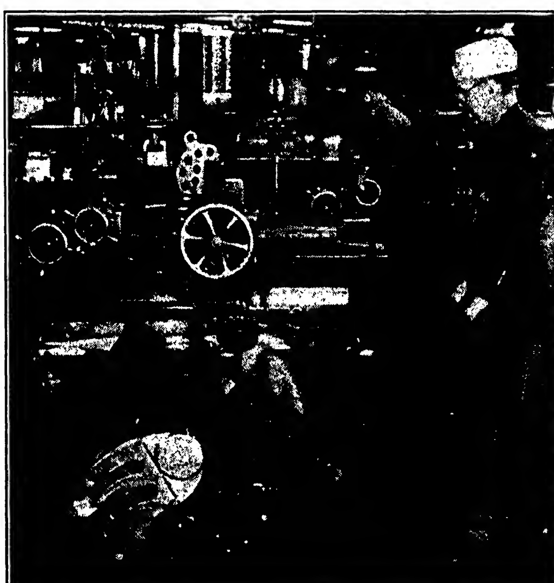
Requested by ______________________ Date ____________

Dept. ______________ CHARGE ORDER NO. ____________

Class of work:	WORK AS FOLLOWS:
Carp. Elec. Mech. Pipe Rig. Lab. Mason	
	By ______________________

Courtesy, E. A. Munson, Plant Engineer, Gould and Eberhardt, and "Factory Management and Maintenance"

FIG. 17.8. Maintenance-department work-authorization slip.



Courtesy, G. H. Tennant Company, Minneapolis

FIG. 17.9. A floor-cleaning machine operating in a crowded area.

well as a notation of the location of each machine. A simple form (Fig. 17.8) is used to authorize work to be done. Naturally, for cost purposes the worker charges his time on his daily work report to the charge order number indicated on the work-authorization card. Materials used are also charged to the same order number. The fundamental rule that ap-

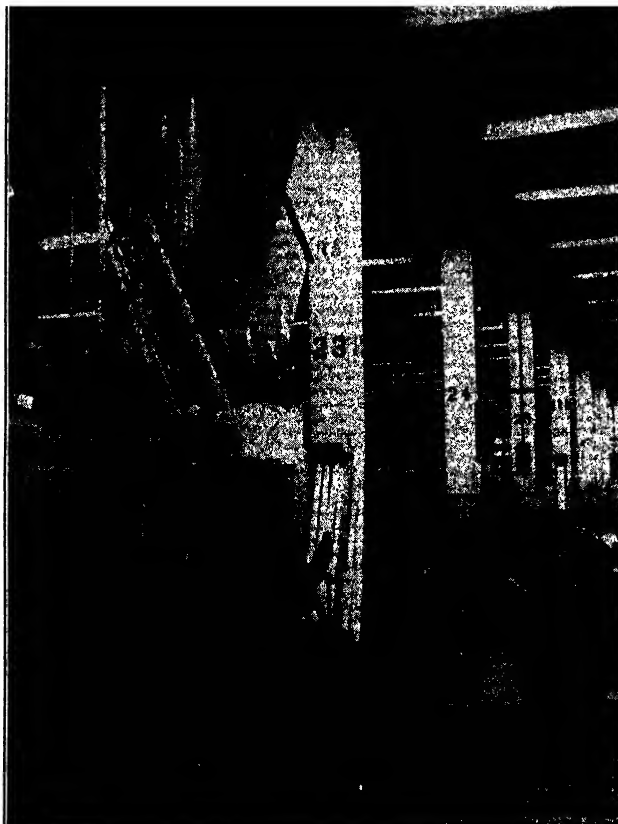
Courtesy, Manning, Maxwell & Moore, Inc., Bridgeport

FIG. 17.10. A properly equipped millwright need not waste time in going back to the shop for tools and minor supplies.

plies to all other records applies also to maintenance records, namely, they should be no more elaborate than is necessary to meet the requirements of the situation. Inventories of repair parts are frequently kept on the bin cards or on a simple card file in the stockroom.

Maintenance equipment. For efficient operations adequate equipment is necessary. Figure 17.9 illustrates an efficient machine for cleaning floors. To avoid unnecessary delays caused by going to the job to find out what is needed and then back to the storeroom for the supplies, a small work stand similar to that shown in Fig. 17.10 is useful. Safety ladders (Fig. 17.11) reduce accidents, give the worker confidence, and

often permit one man to do a job that otherwise would require two men. Where a large number of machines, such as drill presses, are used, an additional machine is frequently kept in reserve to be installed in the place of one needing any major repairs. This enables the machine to be



Courtesy, Wright Aeronautical Corporation and "Factory Management and Maintenance"

FIG. 17.11. An extension ladder mounted on an electric truck makes short work of cleaning and replacing lights.

repaired in the shops, where the work can be done more efficiently, and also avoids production delays. The same situation exists in regard to electric motors and similar equipment. Figure 17.12 illustrates an efficient manner of handling heavy dies.

Salvaging materials. Preventing waste is to be preferred to trying to salvage material to reduce waste. By the very nature of maintenance work, there is some material that would become waste if not properly

salvaged. It is a common sight to see lengths of pipe and joints lying around weeks after a repair or an installation has been made. A salvage section usually saves many times its cost. This work may be extended to the sorting of waste from production as well as maintenance. Floor

Courtesy, Robert MacLatchie, Standardized Factory Facilities, "Factory Management and Maintenance," November, 1945

FIG. 17.12. Proper handling equipment facilitates setup and maintenance work.

sweepings may be put through a magnetic sorting machine to salvage all metal, which may further be sorted to separate the productive material from the scrap metal. Packing cases and lumber received with purchased parts frequently have real value when properly salvaged. The salvage section frequently works closely with the purchasing department, which may sell certain items not needed in the plant.[3]

[3] See "Salvage Program Saves Money and Materials," *Factory Management and Maintenance*, Vol. 103, No. 5, p. 121, for an interesting discussion of this entire subject.

PART V

MOTION AND TIME STUDY

CHAPTER 18

PRELIMINARY CONSIDERATIONS IN MOTION AND TIME STUDY

The need for motion and time studies. When neither the employer nor the employee has adequate knowledge concerning how to perform a given operation most efficiently or how long the operation takes when properly performed, it is but natural that disagreements should arise. An attempt by either side to enforce the basis that it has arbitrarily set up results in a dispute, which is usually settled by a compromise not predicated on facts and not satisfactory to either party. Since the lack of job standards is one of the most frequent fundamental causes of industrial disputes, plants which have carefully set job standards have the fewest disputes of this nature, and such disputes as arise are settled promptly and amicably. A basis exists on which to settle them, and in these plants facts are used rather than opinion, prejudice, connivance, or force, which has been the more usual basis of settlement.

Fortunately from the social viewpoint enlightened employers and labor leaders alike are coming to realize that justice to all concerned can best be attained through the use of facts. Labor leaders have asked for job studies and have cooperated with managers in making these studies. This situation is far different from that existing just before World War I (1914–1918), when Congress was induced to insert a rider to an appropriation bill forbidding the use of any of the appropriated money for "efficiency" studies.

The purpose of job study. Job study or job analysis serves both an engineering and a personnel-management function. Job analysis is used as a basis for writing the *job description* from which the personnel man derives his *job specification.* The job description emphasizes the job requirements, whereas the job specification sets forth the requirements sought in the person who is to perform the work. The job analysis for the personnel man need not be so detailed or technical as the job analysis

used in manufacturing by the industrial engineer. The industrial engineer uses his detailed job analysis as a tool for improving and standardizing methods and working conditions and as a basis for establishing time standards for performing the job.

Improving methods of work. Methods improvement may be the prime objective of job analysis, yet a little extra effort will make possible the securing of accurate times for the operation. On most jobs different operators, if left to themselves, will do the same task in entirely different lengths of time. Differences of 100 per cent in the time two operators take to do the same task are not at all unusual. It will generally be found, after study, that such operators are utilizing entirely different methods to perform the job. If the two workers are analyzed, it will be found that one has discovered a number of short cuts, whereas the other is performing a large number of useless or cumbersome motions. It is thus seen that the first step in job study is to determine the way in which the best worker performs the job, in order that some of his methods may be imparted to the poorer workers. The next step is to try to develop a standard method, which may be an improvement over the best method used up to that time. This standard method not only will improve all existing methods of working, but also will include the utilization of standard equipment for the job and will determine and, if possible, eliminate the causes of fatigue incident to the job. The third step in improving methods of work is to teach all the employees the new, standardized method.

Motion study. Motion study is the simplest form of job study and always constitutes the preliminary portion of a job study, even if a more elaborate study, such as a motion and time study, is contemplated.

The simple motion study of a job in its general elements may reveal many losses and useless motions without any consideration of the time element. It is not necessary to hold a watch in one's hand to know that a worker who must walk a dozen feet to secure material for his machine or to deposit the finished product of his operation can have his work arranged more effectively. General motion study is likely to yield valuable information for the improvement of standards of equipment, and the elimination of useless motions is often one of the best ways of reducing fatigue.

Frank B. and Lillian Gilbreth popularized motion study with the publication of their interesting book, *Motion Study,*[1] in 1911, about the time of the general increase in interest in the management movement. Gilbreth's attention had been forcibly drawn to wasteful operation methods

[1] Published by D. Van Nostrand Company, New York.

in the brick-laying trade through his connection with the contracting business. He had found, for instance, that bricks were dumped in a pile somewhere near the bricklayer by his unskilled assistant and that the bricklayer would take two or three steps over to the pile of bricks, pick up a brick, walk back to the point in the wall where he was going to put it into position, give it several twirls, so that the right side for laying would be upward, and then proceed to put it into place. He also found that there were a large number of similar waste motions in connection with the placing of the mortar. From these observations he developed certain standard equipment, such as a packet for holding the bricks at a proper level and with the right side already up, and a nonstooping scaffold, which changed in height as the wall was built up. Through observation he then developed the best methods of utilizing this equipment. Gilbreth's studies made little dent upon the building industry, however, largely because of union opposition to increasing efficiency.

The Gilbreths also studied the procedures used by the office worker. In the handling of outgoing mail they immediately saw that there were vast opportunities for economies in an improvement of the methods generally used in large offices. If several thousand letters are being mailed a day, as they are in many industries, the saving of only one motion per letter mailed will result in an enormous net gain. For instance, in one office the girls folding and sealing the letters formerly were permitted to arrange the work to suit themselves. Brief observation showed that there was much room for improvement. Experiments were made to determine in just what order each movement—folding the letter, picking up its inclosure, picking up the envelope, and inserting the letter and its inclosure in the envelope—should be made. First attempts were crude, but they immediately doubled the output of the girls. Further study resulted in improvements that not only eliminated some motions, but also shortened the distance through which the hands had to move in performing the remaining ones. The field of motion-studying office procedures and department-store procedures is a fertile one. Large offices and department stores employ industrial engineers who concentrate on this work.

Effects of making motion studies. Motion studies are constantly being made on an informal basis by all efficiency-minded supervisors. Maximum value from motion studies is secured when scientific procedures are used. A few of these advantages are as follows:

1. Whole methods of performing operations may be changed, and newer and more effective ones found.
2. Moderate changes in method and in equipment may be devised.

3. Data are always secured from which a series of job specifications may be developed.

4. Motion study exerts a salutary influence upon the general morale of an organization when the savings made are shared with the employees.

Motion study and the development of standard equipment are inseparably linked. Frequently, soon after the start of a study, it becomes apparent that the worker can do no better with the equipment at hand, because he is forced to use a series of false motions. Motion study may lead to such standardization of equipment on an operation that no further steps beyond instruction in the proper use of this equipment are needed in teaching workers to perform their jobs. When the results of motion study are used for rate-setting purposes, it is imperative that equipment be standardized within reasonable limits. For example, if a rate is set from the study of an operator on a properly functioning machine, this same rate should not apply on another machine exactly the same in every detail except that it has five per cent more belt slippage. Changes made in the methods used on an operation should always be in the direction of straighter, shorter, quicker motions of a kind which become automatic wherever possible.

Time study. By time study is meant an accurate analysis of the time necessary to perform an operation or some part thereof. It involves all the features of close observation that are found in motion study, and in addition the time element is included. In modern industry, for purposes of job study all work may be placed under two general headings: (1) work done by machines and (2) work done by workmen. Motion study concerns itself especially with a study of the work done by the workman with sufficient consideration of the arrangement of machines and their functioning to insure efficient worker production, whereas time study includes a detailed analysis of both "machine time," or the time taken by the machine in doing its share of the work, and "manual time," or the time taken by the workman. Manual time will usually be found to be of three general classes: (1) the handling of tools used by the workman in connection with the job, (2) the handling of the machine by the workman, and (3) the handling of the material that is being worked upon. Time study implies an intense analysis of all three phases of work.

Objectives of time study. *Improvement of methods and conditions* is at times the only reason for making time studies. Motion studies are frequently the first step in these time studies, but pure motion studies are not so frequently used as time studies. The addition of the time element to the study makes it possible to secure information concerning the amount of work which may be accomplished within a given time. Time studies are used as the *basis of "rate setting,"* or the determination

of wage rates, as well as for production control. Time studies should seldom be used for rate setting without being used at the same time to improve methods or conditions. Time study provides data invaluable in setting rates that are relatively fair in comparison to each other. Time study cannot be expected to set rates that are inherently fair from a cost-of-living or similar standard. It clearly indicates fair relative rates to be paid on the several jobs studied.

Rates, if not based on time studies, are likely to be based on past performances. Standard time, and hence rates based on past performances, are likely to be unsatisfactory. In all factories there are to be found poor workmen and good workmen. A good workman on job A takes an interest in his work and in the mastering of his job. A poor workman on job B is probably indifferent to his work, or it may be that he has never been properly instructed in the right way of working. If the records of poor workmen and good workmen are thrown together throughout a shop as "past performance," the resulting basis of rate setting is likely to be unfair. The poor workman, by learning his job or merely by applying himself, may be able under such conditions to double his pay, whereas the good workman, if the job is one where he has always set a high standard, will get but a slight wage increase, if any. Other difficulties in setting rates on the basis of past performance result from the fact that past records are frequently extremely unreliable. Jobs of the past were frequently made up of different elements from jobs of the present. Conditions under which jobs were performed have often been modified by forgotten changes in equipment, which are not taken into consideration as the new rate is set. Frequently, since the past records are unreliable, it is necessary to resort to bargaining concerning what past performance was. Nothing can be more destructive of the wage fabric of any plant than bargaining over opinions when factual data ought to be available.

The preliminary study. The work of the job-study observer in what may be termed "the preliminary study" is, economically, in many ways more important than the actual recording of times themselves. From a wage-setting standpoint this work is of paramount importance also, because it frequently determines the effectiveness of the final study. The "preliminary study" includes all the work before the recording of the actual observed elementary times. It includes the motion study that is made in order that the work may be done in the most effectual way. It also includes some preliminary time studies taken to check the effectiveness of the motion studies and to determine and record the elements of the task to be timed.

Having selected the operator to be studied, the observer should spend some time acquainting himself with the work and all conditions which affect it. He should observe the conditions under which the raw material is furnished the operator and the facilities which the operator has for disposing of the finished product. He should familiarize himself with the quality of the work demanded and the degree of accuracy required. He should see that the necessary equipment for the operator effectively to perform his task is provided and at hand, and, if the operation is a machine one, he should see that there is a sufficient supply of power to drive the machinery to best advantage. Abnormal conditions should be remedied during this preliminary study. Full information should be secured concerning the standards of accomplishment on the job in the past, in order that comparative records may be available after the job has been studied, changed, and timed.

Selecting the elements to be timed. Preliminary job studies, in determining the elements to be timed, must necessarily include a detailed study of the methods of job performance. It is in such studies that analysis is made of the motions that the worker takes in doing the work, and it is through the elimination of useless motions and the providing of standard equipment that many of the savings incident to job study are made. In order satisfactorily to make a motion study, and in order to secure the basis for an accurate time study, it is important that the job be broken down into its elements. Only by a study of the elements is it possible to determine whether the work is being done in the best and cheapest way. An *element* of an operation may be defined as a single continuous and distinct motion or motions of a worker or machine of relatively short duration, the termination of which is indicated to the observer through sight, sound, or touch. In driving a screw, one element consists of placing the screwdriver in position, and another the continuous twisting of the screwdriver while driving the screw. A more complex operation is necessarily made up of a correspondingly greater number of elements, but each of them must be continuous and distinct. For motion study and the improving of methods in time study, it is important that each separate element, however small, be analyzed. In actually recording the times, after the method has been established, it is usually desirable to combine several successive short elements, in order that the watch may be read more easily during the progress of the study. It is extremely unwise to try to observe and record elements which follow each other in successions of only a few hundredths of a minute, since an error in the reading of the time on the stop-watch may be as great as or greater than the elapsed time for the element in question. For practical purposes an operation should not be broken down into elements any

of which are less than about 0.03 to 0.05 minute in duration, particularly if the continuous method of time study is to be used.

In time studies, for rate setting, the extent of separation of the elements is determined by the nature of the operation and the length of the elements. For instance, if the product is standard, not varying from day to day, and is made by repeating the same operation or set of operations, it probably will be wise to study the work from the standpoint of complete jobs, possibly lumping the minor elements together. Such time studies may be termed "operation time studies." [2] If the product varies considerably and is made by a series of operations, the elements of which may quite conceivably also be found in other operations on the same or similar products, it will be found extremely undesirable to lump any elements, because the time for each separate element may be desired in order that they may be regrouped to ascertain the time for the other operations. Thus, by taking a series of time studies on a number of more or less fundamental operations and elements in a shop, it may be possible to arrange and combine data in such a manner that the proper time of performance may be secured for practically every job that the shop may perform, without taking new studies. Such time studies may be called "fundamental element time studies," and in them the time for each separate element is carefully secured.

After the elements have been determined, they are noted in the space provided for them on the observation sheet. An examination of Fig. 19.2, p. 282, shows that the various elements running across the top of the page under the heading "cycle or line number" comprise eleven distinct items. When items 12 and 13, "Get new drill" and "Get new box," are timed, they are not a part of each operation. The standard method of performing the operation is thus determined, with all possible improvements in equipment and method already accomplished, or note is made to provide for further improvement at a later date.

Therbligs. Frank B. Gilbreth designated certain subdivisions of a motion cycle which he thought common to all kinds of work as *therbligs* (*Gilbreth* spelled backwards, except for the *th*). Gilbreth listed seventeen therbligs (see Fig. 19.7, p. 291, for symbols). Professor Barnes, whose list is used below, has classified eighteen therbligs. Other investigators have used a different number of therbligs. The therblig is supposed to represent an elemental motion. The student should not infer that all motion- and time-study men in practice actually use therbligs. They are valuable for detailed studies, the data from which

[2] The term "operation time studies" is also applied to studies in which the over-all operation times are taken without breaking them down into their elements.

may be used in other studies. The most common ones in use are as follows:

1. *Search*[8] (Sh.) refers to that part of the operation cycle during which the hands or eyes are trying to locate the object.

2. *Find* (F.) occurs at the end of *search* and is in reality more of a mental reaction than a bodily movement.

3. *Select* (St.) represents the actual sorting out of one object from among two or more objects. (The three therbligs, *search, find,* and *select* are frequently combined into the one therblig, *select.*)

4. *Grasp* (G.) involves the actual taking hold of the object.

5. *Transport loaded* (T.L.) refers to the actual moving of the object from one place to another.

6. *Position* (P.) consists in adjusting the object so that it will be ready to fit into the location for which it is intended.

7. *Assemble* (A.) begins as the object starts to move into its place in the assembly.

8. *Use* (U.) is the actual manipulating of the tool or apparatus for the achievement of the purpose intended.

9. *Disassemble* (D.A.) is the separating of one object from another.

10. *Inspect* (I.) is the act of checking to see if the work meets predetermined standards.

11. *Pre-position* (P.P.) refers to the placing of the tool or object in such a position that it will be ready for use when needed. This therblig eliminates the therblig *position.*

12. *Release Load* (R.L.) is the actual "letting go" of the object.

13. *Transport Empty* (T.E.) is the moving of the hand empty, either in reaching for an object or returning to a given position after the therblig *release load* (R.L.).

14. *Rest* (R.) is a delay factor provided to enable the worker to recover from the fatigue arising from his work.

15. *Unavoidable Delay* (U.D.) arises either from an interruption in processing or a situation in which one part of the body is prevented from working by another body member.

16. *Avoidable Delay* (A.D.) arises from any delay over which the operator has control.

17. *Plan* (P.) arises from the mental processes involved in making a decision of how to proceed or what to do next.

18. *Hold* (H.) signifies the retention of an object after the therblig *grasp,* during which time there is no movement of the object. Gilbreth included the therblig *hold* in his therblig *grasp.*

The standard symbols and colors for therbligs are shown by the chart on p. 291, Fig. 19.7.

The qualifications of the motion- and time-study engineer. Frequently managers have appeared to feel that anyone equipped with a stop-watch can secure the necessary information for a motion and time study. It is probably for this reason, more than for any other, that job study fell

[8] See Ralph M. Barnes, *Motion and Time Study,* John Wiley and Sons, New York, 1940, pp. 62–66, 107–133, for a detailed description of therbligs and their use.

into disrepute before World War I. The observer must possess an analytical mind and be able to detect small variations in the process from time to time. He must also have enough knowledge of the machine and process to be able to perceive and try out slight mechanical changes which may be called to his attention during his studies.

In addition to the technical qualifications a job-study observer must have confidence in the men with whom he is working and must be able to gain their confidence, as well as that of the superintendent and the foremen. In devising a standard method to perform a job, many possibilities will have to be investigated, and the worker's cooperation is essential, particularly if he has a fund of knowledge based on past experience with the job.

It is presumed that the observer possesses the technical qualifications, because the more he knows about the operation, the better able he will be to suggest alternative methods. On the other hand, if he has gained the confidence of the whole department in which he is working, he has performed a large portion of his task.

Securing confidence is necessary for the following reasons:

1. The full cooperation of everyone is needed for the best results.
2. Secrecy is impossible, even if it should otherwise be desirable. The workmen will hear rumors, which will be worse than the facts, whatever they may be, and these rumors will be confirmed when their rates are changed as a result of the observations that they knew of only by hearsay.
3. In order for the time study to be of maximum value, it is necessary that shop information which has been collected by the foreman and workmen over a period of years shall be at the disposal of the time-study men.

Selecting the operator to be studied. Time-study men generally select the skilled, first-class worker to study. This means that the worker will be of better-than-average ability and will be as superior in quality as he is in quantity. It does not mean that the study will be made on a man who is working at a terrific rate of speed, for such a man is probably turning out no more production than the man who, more skilled, is taking things easier.

The skilled man, rather than the average man, is selected, because allowances will be made in computing time values which will be fair to the average man. The skilled man is better for observation purposes. His motions are uniform, he works steadily, and he is apt to use the best methods and adapt himself more readily to new ones. The erratic work of unskilled employees throws into the calculations all sorts of variables, which have to be ruled out as the computations are made. The experienced time-study observer, acquainted with the nature of the work, soon learns when a skilled operator is working at a normal rate, but he has

more difficulty in making this discovery concerning an unskilled operator. The observer is able to get a skilled man to improve his production if need be, or, on the other hand, is able to recognize unusual ability or excessively rapid movements which cannot be maintained without physical exhaustion. Such cases are properly discounted by the observer, for the desired time standard is one that can be used by persons following instructions and working at a reasonable pace that can be kept up from day to day without undue exertion. Another reason for the selection of the skilled man is that in setting performance standards, as in setting any other standard, the best-known method at the time for the given conditions should be selected as the standard.

On work on which large numbers of persons are engaged and which is to last for some time, more than one operator should be studied in order that without question the resulting rates may represent standard performance.

The conditions of observation have to be varied somewhat for "group work," that is, work in which the operation involves more than one employee. In such work as assembling, the speed of the group is limited largely by the speed of the slowest member. Therefore, in such cases it is necessary to consider carefully the personnel of the group to determine whether it is composed entirely of skilled employees, and, if not, whether such a group can be brought together. Attention should also be given to the operations assigned each member of the group working on the assembly. It is sometimes found that an employee who is thought to be slow and thus holding back his group is in fact doing more work than is justly his share. A rearrangement of his tasks may shift a part of his work to another and thus increase the efficiency of his group. If an individual operator is slower than his group, he should be transferred if possible. If he is kept in the group for some reason, an adjustment of tasks may still result in greater efficiency. When others are carrying a part of the work for a given operator, earnings should be adjusted accordingly. There are two classes of group work, and the necessary skill of all members of the group will vary with the class into which the particular work falls. These classes are: (1) work in which the main part of the operation is performed by one employee, who is merely assisted by other employees, and (2) work in which several employees work together, each doing his portion of the job sequence.

An illustration of the first type of group work is the laying of cloth in a clothing factory. Although the operation is comparatively simple, to handle each type properly demands a certain knowledge of the tailoring trade and the peculiarities of cloth. A cloth which has a very smooth finish may be easily disarranged in pulling one layer over the next,

whereas another which has a heavy nap may tend to stick and must be handled in an entirely different manner. One employee cannot do the work alone because of the width of the cloth, which requires that he have an assistant working on the opposite side of the table. The assistant, of course, must learn how to handle the cloth, but he does not require so much detailed knowledge and hence will not need to be so skilled an employee as the one in charge of the operation. An example of the second type of group operation is any case of continuous assembly, where the speed of one worker is limited by the speed of another, and yet all are doing work of approximately equal importance.

Selecting the operations to be studied. The neck-of-the-bottle operations, the most important in any plant, should be studied first.[4] Even small results achieved there will unquestionably bring large profits with them. It may take longer to get results; but, if the continuation of a job-study program is to be dependent on quick results, the program should never be undertaken.

One danger to be guarded against is an approach to a workman based on superiority rather than on science. A second danger is the taking of time studies when the conditions are not standard. Under such conditions the studies themselves will fall into disrepute, particularly if the workmen know the loopholes in the standards being set. Such a "standard" time will be worthless, since it is based on variables. A third danger is to spend time in making "stunt" time studies. There is always a tendency to spend effort in reducing the time of performance on operations which evidently are poorly carried on. In such cases statistics of percentages of time reduction will be interesting; but, if the operation is an unimportant one, as it is likely to be if huge reductions in performance time are possible, the profit from the study will be small.

[4] See Harold B. Maynard and G. J. Stegemerten, *Operation Analysis,* McGraw-Hill Book Company, New York, 1939, pp. 31–34.

CHAPTER 19

TAKING TIME STUDIES

Time-study equipment. The ordinary time-study equipment consists of a decimal stop-watch, an observation sheet on which the watch readings are recorded as the study progresses, and a board for holding the watch and observation sheet (see Fig. 19.1). Other items frequently used by many time-study men include the tachometer, or revolution counter for measuring machine spindle speeds, and mechanical calculating devices, such as the slide rule and adding machine, or comptometer.

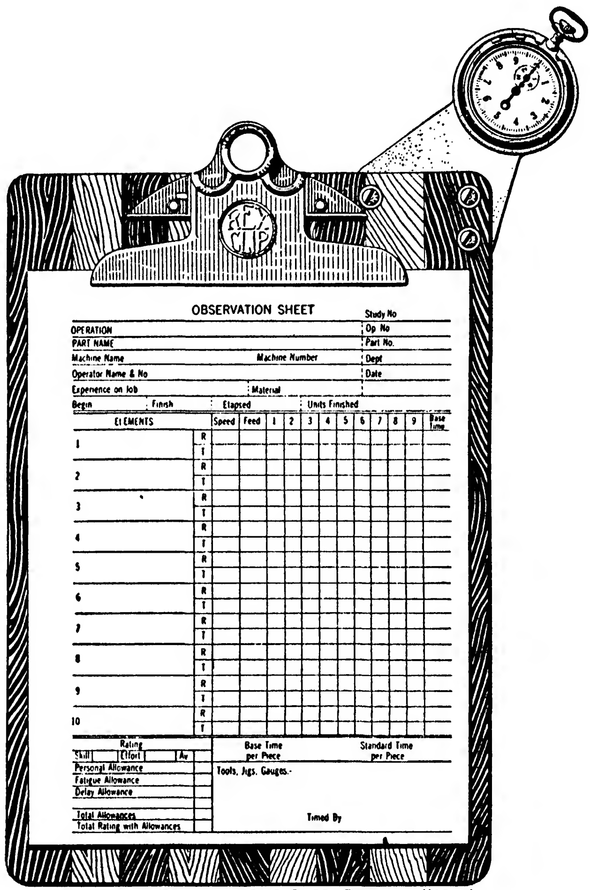
Certain timing devices other than the stop-watch have been developed which have limited applications under special conditions, including the microchronometer, the wink counter, the Marsto-Chron, and the kymograph.

Time-study sheet. Many different forms of observation sheets have been devised. The one shown in Fig. 19.2 will be used as the basis for this discussion of making time studies. It is selected because it is a composite of the best features of many observation sheets. Its adoption by many companies in a wide variety of industries is indicative of its adaptability to almost any type of practical time-study work. In any event, the observation sheet must have space for a full description of the operation and the conditions under which it was taken, with the conditions illustrated, if practicable; space for entering the times of the various elements as they are observed; and a series of columns concerning the time of each element and the proper time for the whole operation.

The stop-watch. Two types of stop-watches are in common use for time-study work: the decimal minute and the decimal hour watches. In both types the principal dial is divided into 100 divisions, and the smaller dial into 30 divisions. The small hand moves one division on the small dial while the large hand makes one complete revolution. Thus the watch cycle includes 30 complete revolutions of the large sweep hand. On the decimal minute watch the sweep hand makes one revolution per minute, or 60 revolutions per hour; but, since the small hand accumulates 30 revolutions of the large hand, the watch has a total cycle of 30 minutes or one-half an hour. With 100 divisions on the dial, each division repre-

sents 0.01 minute, and this is the smallest time value which can be read with practical accuracy on the decimal minute watch.

The decimal hour watch has the same number of divisions on each dial as the decimal minute watch, but the large hand makes 100 revolutions



Courtesy, Ralph M. Barnes, "Motion and Time Study"

Fig. 19.1. Stop-watch study board with observation sheet for recording data taken by the continuous method.

per hour instead of 60 as on the minute watch. Since the large dial has 100 divisions, and the hand makes one revolution in 0.01 hour, each division represents a time value of 0.01×0.01 or 0.0001 hour, and this is the smallest time value which can be read with practical accuracy on the decimal hour watch. The small hand accumulates 30 revolutions of the large hand, or 0.30 hour. The cycle of the decimal hour watch

STUDY NO.	R 75
DATE	8-13-46
SHEET NO.	1
OF	1 SHEETS
STUDY STARTED	10:00 a.m.
STUDY ENDED	10:35 a.m.
ELAPSED TIME	HRS. MIN. 35
STYLE OR PART NO.	M 4311 - 2
OPERATION NO.	50
PART NAME	Collar
OPERATION	Drill, Counterbore, and Ream

CYCLE OR LINE NUMBER

Element No.	Description
1	Pick up new casting, place into fixture, tighten two screw clamps.
2	Lower spindle and engage feed.
3	Drill one hole 1¼" Dia. x 4½" deep. Power feed.
4	Raise spindle, remove drill. Quick-change chuck to counterbore. Change speed.
5	Lower spindle, engage feed.
6	Counterbore 1 21/32 Dia. x 1" deep.
7	Raise spindle, remove Ctrbr, chuck reamer. Change speed
8	Lower spindle
9	Hand-feed reamer through drilled hole 1½ Dia. x 3⅞ deep
10	Raise spindle, remove reamer, chuck drill. change speed.
11	Loosen clamps, remove casting from jig, set aside to box.
12	Drill dull. Get new drill from tool room.
13	Get new box of castings. 25 pieces per box.

Cycle	1 T	1 R	2 T	2 R	3 T	3 R	4 T	4 R	5 T	5 R	6 T	6 R	7 T	7 R	8 T	8 R	9 T	9 R	10 T	10 R	11 T	11 R	12 T	12 R	13 T	13 R
1	18	00 18	6	24	150	174	9	83	4	87	36	223	5	28	6	34	27	61	7	68	12	80				
2	20	300	7	307	149	456	7	63	6	70	37	507	7	14	5	19	28	47	7	54	13	67				
3	19	86	~~11~~	497	151	648	6	54	6	60	35	95	6	701	5	06	35	41	6	47	~~16~~	63				
4	~~30~~	93	7	800	150	950	7	57	5	62	38	1000	5	05	5	10	26	36	~~25~~	61	14	1075	629	1704		
5	20	24	6	1730	150	1880	~~13~~	93	5	98	36	1934	6	40	6	46	28	74	7	81	13	94				
6	21	2015	6	21	149	2170	8	78	4	82	36	2218		M		28	27	55	6	61	12	73				
7	18	91	7	2298	150	2448	6	54	7	61	37	98	7	2505	5	10	26	36	7	43	12	55				
8	22	77	5	2582	150	2732	7	39	5	44	35	79	7	86	4	90	27	2817	6	23	13	36				
9	19	55	7	2862	151	3013	6	19	5	24	36	3060	A ~~13~~	148	5	53	27	80	6	86	12	198				
10	20	218	6	24	152	376	7	83	6	89	37	426	7	33	5	38	28	66	7	73	12	3485			53	3538
11																										
12																										
13																										
14																										

	1	2	3	4	5	6	7	8	9	10	11	12	13
TOTALS T.	1.77	.57	15.02	.63	.53	3.63	.50	.46	2.79	.59	1.13	6.29	.53
NO. OF VALUES USED	9	9	10	9	10	10	8	9	10	9	9	1	1
AVERAGE (SELECTED) T	.197	.063	1.502	.070	.053	.363	.063	.051	.279	.066	.126	6.29	.53
RATING			DDDD										
TOTAL RATING FACTOR	.95	.95	1.00	.95	.95	1.00	.95	.95	1.05	.95	.95	.90	.95
ELEM. BASE TIME	.187	.060	1.502	.067	.050	.363	.060	.048	.314	.063	.120	5.660	.500
OCCURR. PER UNIT	1	1	1	1	1	1	1	1	1	1	1	1/100	1/25
BASE TIME PER UNIT	.187	.060	1.502	.067	.050	.363	.060	.048	.314	.063	.120	.057	.020

Rating factors: Ideal A; Excellent B; Good C; Standard D; Fair E; Poor F.

FOREIGN ELEMENTS

SYM.	R	T	DESCRIPTION
A	3065 / 140	.75	Talk to supervisor
B			
C			
D			
E			
F			
G			
H			
J			
K			
L			
M			
N			
P			

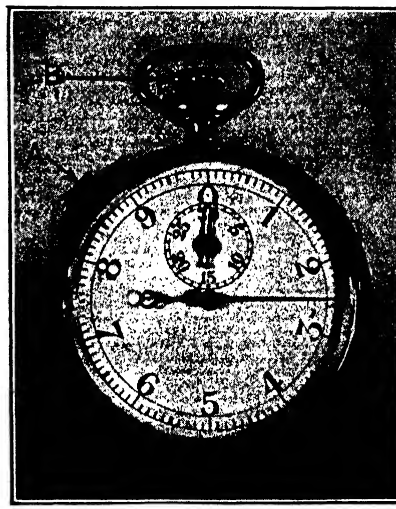
OPERATOR'S NAME	Bill Jones
OPERATOR'S NO.	C-350
OBSERVER	H.B.R.
APPROVED:	

Designed by H. B. Rogers 7-8-46.
1946 NORTHWESTERN UNIVERSITY

Courtesy, H. Barrett Rogers

FIG. 19.2. Observation side of time-study sheet. For convenience, the watch readings shown in the "R" columns may be recorded in pencil. The subtracted times shown in the "T" columns, as well as all other calculations and identification data, should be recorded in ink for permanency.

therefore is only 0.30×60 or 18 minutes, instead of 30 minutes as on the decimal minute watch. Decimal hours are more convenient for cost-accounting and payroll purposes because wage rates usually are considered as "hourly" rates, but the average worker has more difficulty in comprehending time values expressed in decimal fractions of an hour than those expressed in minutes. Furthermore, machine speeds customarily are rated in terms of minutes, such as revolutions per minute or strokes per minute. The decimal minute watch therefore is more widely used.



Courtesy. Ralph M. Barnes, "Motion and Time Study"

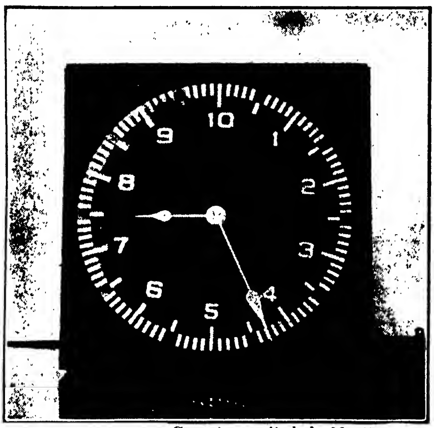
FIG. 19.3. Stop-watch.

On the decimal minute stop-watch shown in Fig. 19.3 the hands may be started or stopped, without resetting, by moving slide *A*. Pressure on the stem *B* resets both hands back to zero, whether the watch is running or has been stopped. If the hands have not been stopped by the slide *A*, they will remain at zero as long as the stem *B* is held down but will start as soon as the pressure is released. It is this ease of resetting the hands to zero and starting them again by a quick pressure and release on the stem that makes "snap-back" readings possible.

For all but the most rapid elements, or for micromotion studies, the stop-watch remains the most practical timing device for most time-study work. Perfectly satisfactory time studies can be made with any ordinary pocket or wrist watch, especially if it has a sweep second hand; but the times necessarily will be recorded in minutes and seconds, and extra calculations will be necessary to convert the seconds into minutes. The principal advantage of the stop-watch is the convenience in starting and stopping the hands and resetting them back to a zero starting point. In addition, the outer dial usually is divided into 100 divisions so that fractions of revolutions of the hand can be added more easily as decimals.

The motion-picture camera. Frank B. Gilbreth also utilized the motion-picture camera in determining time values, by placing a special clock or microchronometer (Fig. 19.4) in the field of vision and obtaining the "therblig times" from an analysis of the film. He built up very satisfactory arguments for the utilization of this method where the elements are short and the work is on a standard product.

Modern motion-picture cameras used in photographing operations are frequently equipped with electric motors that operate the camera at constant speeds. By counting the frames that cover a particular operation, the exact time elapsing may be determined. Thus the moving picture not only becomes a permanent record of the operation but a timing device as well. It provides an accurate record of everything that transpires. It is possible to restudy the operations scientifically without the distraction of production going on at the same time. The film may be run at slow speeds and thus a particular motion may be analyzed in detail. Some operators are so fast that the human eye can scarcely detect their movements. By the use of the motion picture their motions may be slowed down for analysis, and exact time values determined. For instance, it is possible to determine the exact time required for an operator to shift his eye and focus on an object. This would be practically impossible by any known technique other than motion-picture analysis. Waste motions may be studied not only by the observer but also by the operator himself. The motion picture thus becomes not only an excellent device for correction but also a valuable aid in instruction.



Courtesy, Ralph M. Barnes, "Motion and Time Study"

FIG. 19.4. Electric motor-driven microchronometer. The large hand makes 20 revolutions per minute, and the small hand makes 2.

The use of motion pictures in time and motion analysis is somewhat expensive but by no means prohibitive. The expense increases proportionately to the length of the operation cycle studied. Relatively few time-study men are trained in the use of the motion-picture technique.

Porter's "wink counter." The microchronometer dial must be rather large for the divisions to be seen easily in the moving pictures and takes up such a large portion of the picture that the camera must be too far away from a normal-sized bench top for the hand movements to be analyzed easily. Furthermore the operator constantly is aware of the large clock, particularly of its rapidly moving hands, and the psychological effect is undesirable. To avoid some of these difficulties, Professor David B. Porter of New York University devised a "wink counter." This is an electric clock mounted in a relatively small box and having

three revolving discs with large numerals on the edges; it is read like an automobile speedometer. It can be read accurately to 0.005 minute, and for use in motion pictures a revolving helix permits still smaller readings. The device is small, requiring less than one quarter as much space in the picture as the microchronometer, yet the large numerals make it easy to read. Without the fast-moving hands it is less annoying to the operator. However, it does require an electrical connection, which is not always conveniently available.

The Marsto-Chron. For time studies with a stop-watch the observer not only must watch the operation, but he also must read the watch and then look at the paper to record the watch reading in the proper place. To permit the observer to focus his attention on the operation, the Marsto Instrument Company, Waban, Massachusetts, has developed the Marsto-Chron. The beginning and end of the operation are recorded by pressing two keys, and the end of each element is recorded by pressing one key. Pressure on either key depresses a type bar, making an instantaneous mark on a narrow crosswise motor-driven tape which moves at the rate of 10 or 20 inches per minute, depending upon the motor drive used. Time values of 0.01 minute or less can be recorded with considerable accuracy, and the observer has no watch to read or readings to record at the time of taking the study. On very short, highly repetitive operations, and those in which the element sequence never changes during successive cycles, the time values can be identified with the proper elements according to the sequence of occurrence on the tape; and the values can be measured by sliding the tape under transparent scale, calibrated in minutes to correspond with the running speed of the tape. If minor interruptions occur during the cycle or if the element sequence changes, however, it is practically impossible to identify the element to which a certain time value belongs. In its practical application, therefore, the Marsto-Chron is limited to use on short cycles of not more than perhaps 10 or 12 elements, and to operations in which the elements are less than about 0.05 minute.

Barnes' kymograph. The kymograph (Fig. 19.5), developed by Dr. Ralph M. Barnes at the University of Iowa, is similar in principle to the Marsto-Chron. It uses a motor-driven tape, such as adding-machine tape. Three or four pencils (or possibly more) rest on the tape, making continuous lines lengthwise of the tape. The pencils are controlled by solenoids which, when actuated, cause the pencils to move a short distance crosswise of the tape, thereby making jogs in the pencil lines. Distances between the jogs indicate the time values, and a considerable variety of elements can be identified by the various combinations of the jogged lines. The solenoids are actuated electrically by photocells, push

buttons, or other contacting devices. Considerable time is required to interpret the data on the tape into usable form, but with a fast-moving tape extremely small time values can be measured accurately. With coded identification of the elements, and the several means available for actuating the solenoids, the kymograph is a convenient laboratory instrument for certain types of research problems.

Courtesy, Ralph M. Barnes, "Motion and Time Study"

FIG. 19.5. Electrically operated kymograph measures and records time. Paper tape passes through the machine at a uniform speed of 2000 inches per minute, and solenoid-operated pencils mounted above the tape may be used to mark the beginning and end points of therbligs or of other subdivisions of an operation to be timed.

Although these various instruments are valuable research tools, they are rarely used in industry for every-day operations. The stop-watch is the primary tool of the time-study engineer. The camera is secondary to the stop-watch, and the other instruments are by comparison relatively unimportant when viewed from the standpoint of actual use.

Preparation of the observation sheet. In establishing the conditions of studies taken for rate setting, it is essential that the observer see that they are standard and that they can be repeated at any time. Complete information makes possible not only the checking of the study while it is being taken but also the checking of it at some future date when the rates set on it as a basis may be questioned. If conditions are carefully noted, they may be readily re-established at any future date, or at least it may be determined wherein new conditions differ.

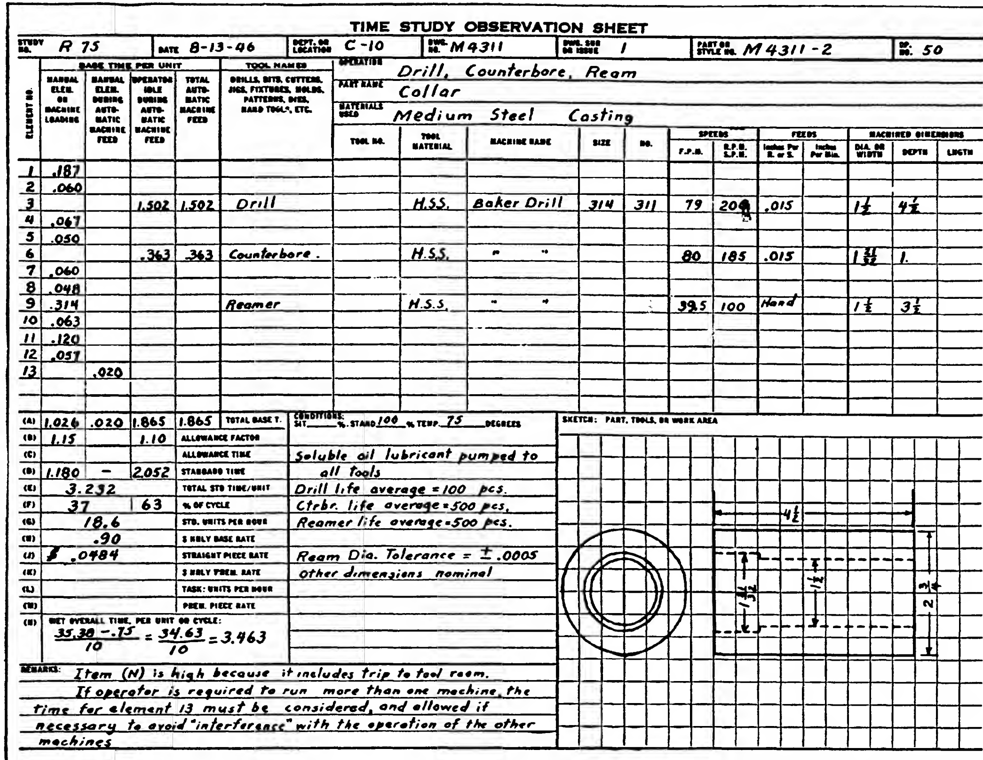
Complete identification of the job will include such items as date of observation; name of observer; name of worker and perhaps his qualifications; material identification; equipment and tools; name and part number of the finished product; position of the operator—whether sitting or standing; height of work place; temperature, light, and possibly relative humidity; cutting speeds and feeds; sketch showing important dimensions (or occasionally photographs); and any other possible data which may have any bearing on the manner of doing the work. Many time studies are relatively worthless for later use because the observer failed to record complete details of the job conditions. Figure 19.6 illustrates the pertinent data that should be recorded.

Approach to the operator. On completion of the preliminary work the observer is ready to begin the actual observations and recording of times. To secure accurate results the observer must stand in such a position that he can see exactly what the worker is doing and, as far as possible, exactly what the machine is doing also. The observer should be behind, not in front of, the employee. This will lessen the strain of being observed, which increases if the worker tends to look up to see what the observer is doing. Ordinarily the correct position will be about 5 to 6 feet in the rear and to the right or left of the employee. If the operator must stand, the observer also should stand, out of courtesy to the worker. If the worker sits during the operation, the observer may sit if he can do so without being conspicuous or in the way of the operator or other workers. In general, however, the observer should stand in order to see the operations better, to be more alert, and to make more accurate recordings on his study.

The number of observations required. Time study involves a sampling procedure. As in all sampling techniques a sufficiently large number of readings must be taken to obtain fairly representative times for the operation.

The number of observations of any operation that are required in order to secure sufficient information will vary with the type of work involved. In the illustration (Fig. 19.2) 10 observations were taken. If a comparatively long time is necessary to perform each of the elements of the operation and it is clearly seen that the operator has achieved a rhythm that results in approximately a uniform rate of work, only a few observations, for instance, 10 to 20, might be necessary. This is especially true if the job involves work on automatic machines, with but a small percentage of handling time.

On operations of less than one-half-minute duration, perhaps as many as 100 cycles should be timed. On longer operations, of say 15- to 30-minute duration, from 5 to 10 cycles may be sufficient. In jobbing shops,



TIME STUDY OBSERVATION SHEET

STUDY NO.	DATE	DEPT. OR LOCATION	DWG. NO.	DWG. SUB OR ISSUE	PART OR STYLE NO.	OP. NO.
R 75	8-13-46	C-10	M4311	1	M4311-2	50

OPERATION: Drill, Counterbore, Ream
PART NAME: Collar
MATERIALS USED: Medium Steel Casting

ELEMENT NO.	MANUAL ELEM. OR MACHINE LOADING	MANUAL ELEM. DURING AUTOMATIC MACHINE FEED	OPERATOR IDLE DURING AUTOMATIC MACHINE FEED	TOTAL AUTOMATIC MACHINE FEED	TOOL NAMES (DRILLS, BITS, CUTTERS, JIGS, FIXTURES, MOLDS, PATTERNS, DIES, HAND TOOLS, ETC.)	TOOL NO.	TOOL MATERIAL	MACHINE NAME	SIZE	NO.	SPEEDS F.P.M.	SPEEDS R.P.M. S.P.M.	FEEDS Inches Per R. or S.	FEEDS Inches Per Min.	MACHINED DIMENSIONS DIA. OR WIDTH	DEPTH	LENGTH
1	.187																
2	.060																
3			1.502	1.502	Drill		H.S.S.	Baker Drill	314	311	79	208	.015		1½	4½	
4	.067																
5	.050																
6			.363	.363	Counterbore.		H.S.S.	" "			80	185	.015		1 31/32	1.	
7	.060																
8	.048																
9	.314				Reamer		H.S.S.	" "			39.5	100	Hand		1½	3½	
10	.063																
11	.120																
12	.057																
13		.020															

(A)	1.026	.020	1.865	1.865	TOTAL BASE T.
(B)	1.15		1.10		ALLOWANCE FACTOR
(C)					ALLOWANCE TIME
(D)	1.180	–	2.052		STANDARD TIME
(E)	3.232				TOTAL STD TIME/UNIT
(F)	37		63		% OF CYCLE
(G)	18.6				STD. UNITS PER HOUR
(H)	.90				$ HRLY BASE RATE
(J)	$ .0484				STRAIGHT PIECE RATE
(K)					$ HRLY PREM. RATE
(L)					TASK: UNITS PER HOUR
(M)					PREM. PIECE RATE

(N) NET OVERALL TIME, PER UNIT OR CYCLE: $\frac{35.38-.75}{10} = \frac{34.63}{10} = 3.463$

CONDITIONS: SIT.____%. STAND 100 %. TEMP. 75 DEGREES

Soluble oil lubricant pumped to all tools
Drill life average = 100 pcs.
Ctrbr. life average = 500 pcs.
Reamer life average = 500 pcs.
Ream Dia. Tolerance = ±.0005
other dimensions nominal

REMARKS: Item (N) is high because it includes trip to tool room. If operator is required to run more than one machine, the time for element 13 must be considered, and allowed if necessary to avoid "interference" with the operation of the other machines

SKETCH: PART, TOOLS, OR WORK AREA

Courtesy, H. Barrett Rogers

FIG. 19.6. Write-up side of time-study sheet (back of Fig. 19.2), showing the method of calculating the standard allowed time for the operation, as well as data essential for future use of the time study for comparisons and the development of standard time data. The sketch may be free-hand and should be sufficiently complete to show the shapes and dimensions directly associated with the operation.

where orders are small, the observer may be unable to obtain readings on more than 1 or 2 cycles.

Taking the time study. Figures 19.2 and 19.6 portray the steps in taking a time study. Across the top are shown the descriptions of the various elements determined for the purpose of this study. In taking the study the observer will record elapsed time on the observation sheet, as indicated in the example. It will be noted (Fig. 19.2) that in the space below the elements will be found two sets of figures expressed in minutes and hundredths of a minute. Those in the space below "R" represent the continuous times or "readings," recorded as the study is made for the operation as a whole. Those in the space below "T" represent the times for the elements, which are computed from the continuous times after the observations have been completed. In the accompanying study the watch ran continuously from the beginning of the study until the end. For instance, in the ninth observation under the seventh element the letter *A* is inserted. In the extreme right-hand column it is explained that the worker talked to his supervisor. The advantage of this system is that necessarily all happenings during the progress of the operation must then be noted and explained on the observation sheet. This practice is particularly desirable in a job study for developing standard conditions, so that all interruptions that have occurred, of whatever character, may be studied with a view to prevention of recurrence. The disadvantage lies in the necessity of entering three or more figures instead of two for each observation taken after the pointer of the stop-watch has made one complete revolution. This objection may be obviated, as is shown in Fig. 19.2, by merely recording the total figures once or twice during each cycle. A second method of reading the watch is to start over again at the end of each cycle. A third method is to snap back the watch at the end of each element. This method is not accurate for short elements. It does, of course, have the advantage of recording only the actual times.

It will be noticed that elements 1 through 11 occur regularly in every cycle. Certain productive elements, however, do not occur on every cycle but may occur at rather regular intervals for some multiple number of cycles. For example, the reading on line 4, column 12, indicates that the drill was considered too dull for good performance and the operator went to the toolroom for a new drill, the interruption consuming 6.29 minutes. Also on line 10, column 13, it is shown that 0.53 minute was required to change containers. Neither of these two activities occurred as regular elements within the normal cycle, but they are required at regular intervals in the process. Therefore they are considered as productive elements and are shown along with the regular elements, but they must be apportioned to the cycle time as explained later.

Securing the time for each element. The time for each element is secured by subtracting the continuous time recorded below the prior element from the continuous time for the element in question. For instance, on line 8, element 1 (Fig. 19.2), the continuous reading is 2577 (the 25 is omitted in recording), and the reading for element 2 is 2582. By subtracting 2577 from 2582 the time for element 2 is found to be 0.05 of a minute.

These individual times are usually accurate, because the stop-watch hand will make three forward moves each 0.01 minute. Thus, if the hand were stopped, it would be possible to read down to 0.003 minute. However, 0.01 minute is a close enough observation for almost any purpose, for the observer will ordinarily read up 0.01 minute as often as he will read down 0.01 minute, and any slight errors in observation of this nature will automatically adjust themselves.

Micromotion analysis. The making of a micromotion study in the form of a simo chart requires considerable time and in many instances is not justified (see Fig. 19.7). It is, however, an excellent training device and well worth making from time to time for training purposes if for no other reason. Figure 19.8 is illustrative of the detail that may be shown for a link-forming operation. Either the simo chart or the analysis sheet of the micromotion study may be made independently. It is not necessary to make the simo chart in order to make the micromotion study.

A micromotion study may be made as the result of a careful analysis of an operation with or without the aid of a motion picture of the operation. A motion picture of the operation is particularly helpful in that it facilitates getting all the detailed actions of both hands or other members of the body if they are involved. A micromotion analysis is particularly valuable in calling attention to time when one hand is idle; this idle time may be avoided by a rearrangement of the sequence of operations. Because of this fact the first micromotion analysis may be merely a tool to aid in perfecting the standard operation desired. When all corrections have been made, a final micromotion study serves as a valuable record of the standardized operation. In the construction of what is expected to be a final motion analysis, further improvements suggest themselves.

Synthetic time studies. When careful data covering various elements have been accumulated, these data may be used in establishing synthetic time values for similar operations. This is true especially when there are many different operations of a similar class of work, such as that on lathes, drill presses, or punch presses. These elemental times, to be of use in building synthetic times, should be established with great care

under standard conditions.[1] When this has been done and a new job is to be undertaken, all that is necessary is to construct a detailed operation sheet for the task and select the appropriate elemental times for each

Name of Therblig	Therblig Symbol		Explanation-suggested by	Color	Color Symbol	Dixon Pencil Number	Eagle Pencil Number
Search	Sh.		Eye turned as if searching	Black		331	747
Find	F.		Eye straight as if fixed on object	Gray		399	747½
Select	St.	→	Reaching for object	Gray, light		399	734½
Grasp	G.	∩	Hand open for grasping object	Lake red		369	745
Transport loaded	T.L.		A hand with something in it	Green		375	738
Position	P.	9	Object being placed by hand	Blue		376	741
Assemble	A.	#	Several things put together	Violet, heavy		377	742
Use	U.	U	Word "Use"	Purple		396	742½
Disassemble	D.A.		One part of an assembly removed	Violet, light		377	742
Inspect	I.	0	Magnifying lens	Burnt ochre		398	745½
Pre-position	P.P.		A nine-pin which is set up in a bowling alley	Sky-blue		394	740½
Release load	R.L.		Dropping content out of hand	Carmine red		370	744
Transport empty	T.E.		Empty hand	Olive green		391	739½
Rest for overcoming fatigue	R.		Man seated as if resting	Orange		372	737
Unavoidable delay	U.D.		Man bumping his nose, unintentionally	Yellow ochre		373	736
Avoidable delay	A.D.		Man lying down on job voluntarily	Lemon yellow		374	735
Plan	Pn.		Man with his fingers at his brow thinking	Brown		378	746
Hold	H.		Magnet holding iron bar	Gold ochre		388	736½

Courtesy, Ralph M. Barnes, "Motion and Time Study"

FIG. 19.7. Standard symbols and colors for commonly used therbligs.

element from time values already established for similar work. The total of the elemental times, when adjusted for allowances for fatigue and other conditions, gives the operating time allowed for the operation.

[1] See Ralph M. Barnes, *Motion and Time Study,* 1940, pp. 288–300, for an excellent discussion of the determination of time standards from elemental time data.

MICROMOTION STUDY

SIMO CHART

PART Link for typewriter DEPARTMENT 9 FILM NO. C18

OPERATION Form link for typewriter OP. NO. G11

OPERATOR A.S.Sanders A2 DATE 2-15-37 MADE BY S.A.R. SHEET NO. 1 OF 1

DESCRIPTION LEFT HAND	TIME
Returns clamping lever and releases it	2
Moves hand to fixture	3
Grasps formed link in fixture	6
Carries formed link to left and releases it	3
Moves to clamping lever and grasps knob	3
Moves lever to extreme left	3
Holds lever in this position	6
Returns lever to original position and releases it	3
Moves hand to fixture	3
Grasps piece, turns it end for end in fixture and releases it	8
Moves to clamping lever and grasps knob	3
Moves lever to extreme left	3
Holds lever in this position	8
Returns clamping lever and releases it	

TIME	DESCRIPTION RIGHT HAND
4	Reaches for material
2	Selects and grasps one piece
6	Carries piece to fixture
6	Inserts piece in fixture and releases it
2	Reaches for forming lever and grasps knob
5	Forms 1st end of link
3	Returns forming lever and releases it
4	Moves hand toward fixture and waits for left hand
4	Moves hand to fixture
8	Assists left hand in turning piece end for end in fixture
2	Reaches for forming lever and grasps knob
5	Forms 2nd end of link
3	Returns forming lever and releases it

Courtesy, Ralph M. Barnes, "Motion and Time Study"

FIG. 19.8. Simo chart of link-forming operation.

The use of synthetic standard times enables the production department to plan its schedules even before the first piece has been produced. Such a program is particularly valuable in estimating the cost of producing parts when quotations are asked with only the blueprint specifications available.

Synthetic time studies from elemental body-movement time values. There is a growing interest in the development of time values for elemental body movements. A few companies have made extensive use of this technique. The steps in this procedure are as follows:

1. Separate the operation into its basic elements.
2. Separate each operation element into its therbligs or elemental body movements.
    2.1. If two or more body movements are executed simultaneously, the time required for the longest therblig is controlling.
    2.2. In some cases simultaneous body movements do not have the same time elements as each movement does when executed alone. This difference must be allowed for in computations.
3. Assign time values for each therblig in each operation element.
4. Total the time values for each therblig in each operation element.
5. Add allowances for fatigue and similar conditions to determine the required operating time.

Synthetic time values for industrial operations derived from basic therblig standard times have not as yet received general acceptance in industry. This field for pure research is a fertile one. Should it be definitely established that these body-movement time values are constant or vary in a determinable ratio, this method of establishing operation time values will revolutionize our present method of time and motion study. Under this system the observer would not require a stop-watch or other timing device. He would merely motion-study the operation, establishing carefully the operation elements and their resulting therbligs. He would return to his office, fill in the time values for the body-movement therbligs, and add the machining time [2] required and allowances for fatigue and personal needs to establish the operation time.[3] At least one large manufacturer in Chicago is experimenting with such a program. The results achieved to date seem encouraging.

[2] Machining time can usually be supplied by the manufacturer of the machine. If these data are not available, it would of course be necessary to establish such standard times by actual checking with some type of timing device.

[3] See Walter G. Holmes, *Applied Time and Motion Study,* Ronald Press Company, New York, 1938, pp. 217–280, for an excellent discussion of body movements and time values for them.

CHAPTER 20

ESTABLISHING TIME VALUES BY TIME STUDY

Finding the selected operation time. For illustrative purposes it may be assumed that the method of recording the times in Fig. 19.2, p. 282, has been used. Several methods of working up the time-study results will be described. They may be termed the "average" method, the "minimum" method, the "modal" method, and the "good time" method. They will each be described; but before they are taken up in detail, certain features which are common to them all will be pointed out.

The *first step* in any method is to throw out the "abnormal" times. These are times recorded for individual elements that are clearly in error when compared to the other times recorded. The error may be due to one of the following causes:

1. Some delay which will seldom occur or some variation in the way that the element was performed which will seldom be repeated.
2. The wandering of the worker's attention, for instance, talking to a fellow-workman. A certain degree of lack of attention to a job not only is likely to occur but also is desirable, if undue strain is to be lifted from the workers. Such time as is necessary for this, however, should not be included in operation time but should be added in the form of an allowance, after operation time has been determined. Other allowances must be added in like manner.
3. Some mistakes on the part of the observer in reading the watch, which can generally be detected by the fact that the time of either the preceding or the succeeding element is likely to be abnormal, whereas the sum of the two abnormal times will be approximately the sum of the average times of the two elements.

Striking out abnormal values, either higher or lower than the general average, calls for fine judgment on the part of the observer. Nevertheless, *it may be assumed that any time which varies more than 25 or 30 per cent from the average may be stricken out of the calculations.* On short elements it is not always practical to adhere to the percentage basis. Some observers do not agree with the practice of eliminating the abnormal values. There are a few kinds of work in which the abnormal values should be figured in, when working up the study. These include construction work and repair work.

In the "average" method, which is the simplest, those individual element times which remain after the abnormal readings have been elimi-

nated are averaged. A more appropriate name for this method of selecting the operation time would be the *"selected average"* method. (An occasional observer may use the straight mathematical average or arithmetic *mean* without discarding abnormal times. Such a plan is absurd when some of the readings are obviously abnormal, but it would probably cause no special difficulty if the variations are only on the borderline of being abnormal.) If the average method is used, these average times will also be the average selected times and will be so indicated in the last column of the observation sheet. The selected operation time under this method is found by adding up the average time of the separate elements. This is the simplest method and the one commonly used. The objection to this method is that it may make the individual element times and hence the final operation time too high, because it includes all observations other than those which were abnormal. In adding allowances, these higher times are automatically taken care of, and this method has the effect of giving too much weight to the higher times.

The *"minimum"* method provides for taking the absolute minimum for each element, namely, that time which, in all the observations, was the fastest for any one element, and then adding these together to get the selected operation time. (The minimum method excludes the abnormal times before selecting the minimum.) In this method, therefore, the minimum time and the selected time are the same. This has the effect of materially reducing the selected time below the value which would be found under the average method. For instance, in the illustration given, the selected time for the complete operation cycle of 10 elements (Fig. 19.2, p. 282), would, under the average method, be 1.026 minutes, whereas under the minimum method it would be 0.917 minute. It is generally believed that this method is too severe and is not fair to the workman, even with the addition of allowances, since to choose the minimum time, which might have occurred only once out of 20 observations, usually means taking a time that is just over the 25 per cent borderline and is not quite thrown out.

The "modal" method is one of the two most frequently used. It consists of taking the most frequently recurring element time in the observations as the time for that element. Thus, in element 4 in the illustration, the time 0.07 recurs 4 times, whereas the time which recurs next most frequently is 0.06, 3 times. Therefore, 0.07 would be taken as the selected time for that element. The selected operation time is secured by adding together the various element times thus secured. If two elements recur with equal frequency, usually the average of these elements is taken. The modal time is generally less than the average time and is, of course, always greater than the time secured by the minimum method. The

modal method eliminates the objections to the two previous methods and at the same time gives a selected time which can be achieved, as is evidenced by the fact that it is composed of the elementary times which were themselves most frequently achieved.

The "good time" method is merely the modal method applied with some degree of flexibility. In the good time method a time which recurs with reasonable frequency is selected rather than the one which happens to occur most frequently. The fact that the time recurs a number of times indicates that it can be made, and the justice of this method lies entirely in the interpretation of "reasonable." *A time to be reasonable certainly should appear in from 10 to 15 per cent of the observations. The time selected may presumably be the modal time, but it is likely to be somewhat lower.*

Leveling factor. To the extent that the observed worker varies from the average skilled worker, an adjustment of the time will need to be made in the allowances, or by empirical judgment, or according to some scale that has been derived by experience. If the worker studied is an *average worker,* possessing *average skill,* working under *average conditions,* exerting *average effort,* and maintaining this effort with *average consistency,* the selected operation time will need no adjusting. Some time-study men argue strenuously against any formula type of leveling factor.[1] The technical details of their arguments are too extensive for presentation in the limited space permissible in a book on industrial management. It is undoubtedly true that the use of the table to be described (Table 20.1) requires judgment of the same type that is necessary in making adjustments empirically. The table, however, has at least one value. The observer is definitely required to evaluate at least the four factors of relative skill, effort, conditions under which work was performed, and consistency of work. A conscious effort to evaluate these four factors will tend to greater uniformity in leveling than an over-all estimate not broken down.

The selected time value taken from the observation of the worker is adjusted to correspond to the time that might reasonably be expected of an average worker. This adjustment is accomplished by multiplying the selected time by a leveling factor, which is obtained from Table 20.1, according to the following illustration. Assume that the worker possessed excellent skill (B1), worked under fair conditions (E), exerted good

[1] See Walter G. Holmes, *Applied Time and Motion Study,* Ronald Press Company, New York, 1938, p. 200; also Ralph Presgrave, *The Dynamics of Time Study,* University of Toronto Press, Toronto, 1944, Chapter 6, for an interesting discussion of leveling.

effort (C1), and was average (D) in consistency. The numerical equivalent for each of these factors added to unity algebraically would be the leveling factor, $0.11 + (-0.03) + 0.05 + 0.00 + 1 = 1.13$. Since the observed worker is above the average, it would be expected that his time would be shorter than the time required by the average man. By multiplying the selected operation time by 1.13, the time for the average worker would be determined. This normal time would still have to be corrected for allowances for personal needs, machine set-up time, and other such factors.

TABLE 20.1

PERFORMANCE RATING CHART *

Skill			Effort		
+0.15 +0.13	A1 A2	Superskill	+0.13 +0.12	A1 A2	Killing
+0.11 +0.08	B1 B2	Excellent	+0.10 +0.08	B1 B2	Excellent
+0.06 +0.03	C1 C2	Good	+0.05 +0.02	C1 C2	Good
0.00	D	Average	0.00	D	Average
−0.05 −0.10	E1 E2	Fair	−0.04 −0.08	E1 E2	Fair
−0.16 −0.22	F1 F2	Poor	−0.12 −0.17	F1 F2	Poor
Conditions			**Consistency**		
+0.06	A	Ideal	+0.04	A	Perfect
+0.04	B	Excellent	+0.03	B	Excellent
+0.02	C	Good	+0.01	C	Good
0.00	D	Average	0.00	D	Average
−0.03	E	Fair	−0.02	E	Fair
−0.07	F	Poor	−0.04	F	Poor

* Stewart M. Lowry, Harold B. Maynard, G. J. Stegemerten, *Time and Motion Study*, McGraw-Hill Book Company, New York, 1940, p. 233. Reproduced by permission of the publisher.

Allowances. The normal time secured by multiplying the selected operating time by the leveling factor is not the standard time for rate setting. Certain allowances must be added to cover such factors as the following:

1. Preparation time of the machine. It will be noted that the machine will have to be prepared to do a job only once, although the job may be repeated many times in succession. This is therefore in the form of an allowance rather than an element of the operation.
2. Necessary machine delay.
3. Fatigue of the operator.
4. Personal needs of the operator, oiling machine, etc.
5. Material handling. The operators frequently must move trays or pans of material to and from their machines or benches.
6. Supervision received from the foreman or given to a learner or helper.
7. Getting miscellaneous supplies and tools, replacing broken tools, or grinding tools if the operator grinds his own tools.
8. Machine interference if the worker is operating more than one machine and the cycle becomes unbalanced. One machine may become idle before the operator gets another machine started. The chances for this type of idle time increase with the number of machines operated by one man.

The preparation allowances may sometimes be determined with as much exactness as the selected time. On the other hand, the provision for proper allowance for machine delay, fatigue, personal needs, and other such factors must involve as an element the judgment of the person who computes the allowance. Therefore, *if care is not utilized in making the allowances, any amount of care utilized in timing the operation or selecting the unit times may be voided.*

The determination of the leveling factor is primarily a matter of judgment based upon experience and training. In many cases this is also the basis of allowances, yet it need not be. Careful studies should be made of individual machines, operations, and work centers to provide the data needed for making allowances. Two methods may be used for securing these data: (1) the *all-day delay time-study method* and (2) the *frequency ratio delay method.*

The all-day delay time-study method is the one most commonly used. It consists of making studies of a group of workers or a work center for a period of a day or longer to record and analyze necessary delays. This information is then broken down to correspond to the proper operations and applied as a percentage allowance.

For the frequency ratio delay method [2] the time-study man prepares a small pocket notebook with a separate sheet for each operator within

[2] The author is indebted to Professor H. Barrett Rogers for this description and for his assistance in preparing these chapters on motion and time study.

a general work center.[8] On each sheet is listed productive time and the various classifications of delays that may be expected. Over a period of several weeks or months the observer will make many trips past the workers at various times of the day or week. Each time he passes a worker, he makes a tally mark under the type of activity with which the worker momentarily is occupied. After a minimum of about 500 tally marks have been collected for a work center, a reasonably accurate allowance factor can be determined. Obviously the more tallies available, the more accurately the factor will represent the average conditions. This method is relatively new, and because it is not well known, it is not widely used; it is based on sound principles, however, and has proved highly satisfactory in actual applications. It is economical of the observer's time because the tallies are made while the observer is on his way to perform other duties.

Standard time. The taking of time studies for the purpose of setting rates furnishes a basis on which definite standard times may be set. *The selected operation time is the time in which the operation can be performed by a highly skilled worker under ideal conditions.*

The selected operation time can be "made," but is not usually made. This manifestly would be an unfair basis for the setting of rates. It is desired to fix a time that will be within the ability of any average worker, properly instructed. This time, which is secured by leveling the selected operation time and adding the allowances, is known as "standard time."

The measure of the *fairness* of the standard time which has been set is the ability of the *average worker to make it,* and the ability of the superior worker under good conditions to excel it. One purpose of motion and time study is to set a time which will enable the worker to accomplish the maximum amount of work with the minimum amount of fatigue. It is only with such a time standard that maximum production can be maintained day after day.

The relationship of the allowances to standard time is important. One of the chief criticisms leveled at time study has been that it sets a rate which only the best workers can hope to achieve. This criticism is not valid. The leveling factor reduces the observed time to the normal time that an average worker can make. By adding allowances the normal time becomes the standard time for the average worker, all the factors of the work situation being taken into consideration. Further comments are in order concerning the nature of some of these allowances.

[8] See Robert Lee Morrow, *Time Study and Motion Economy,* Ronald Press Company, New York, 1946, Chapter 16, p. 176, for an interesting discussion of the ratio delay study for allowances.

"Setup"-time allowances. In any type of work that is not purely manual there is involved some preparation of the machine to receive the work that is to be done. The "setup" of the machine from the last job must be changed. The importance of this task, the length of time that it takes, and the frequency with which it must be done differ from job to job and from industry to industry. Preparation time may not always be treated as an allowance. The preparation of the machine may in some cases be regarded as a separate operation, or it may be wiser to regard it as an element of the operation to be performed.

In by far the largest number of operations, the machine is set up once, and then the operation is performed several times in succession before resetting the machine. It is in such cases that a preparation *allowance* is necessary. Illustrations of such jobs are to be found in great number in many industries, for instance, setting up a punch press and a turret lathe in metal-working, a lining machine in stationery manufacture, and a loom in weaving. A setup may be completely or partially like that from the previous operation on the machine. In many cases it is more logical to use the setup time as a separate operation, not including it in the operation time of the pieces manufactured. In other situations the setup time is divided by the average number of pieces usually run, thus giving the setup time as a part of the selected operation time. For instance, if it takes 100 minutes to make a setup for a machine that is to run 1000 pieces, the allowance per piece for setup will be 0.1 minute.

Allowance for personal needs. The time required for personal needs varies more with the individual than with the type of work; however, with the same individual more time will be required for personal needs when performing heavy work or when working under unfavorable conditions of humidity and heat than when doing light work or laboring under more favorable conditions. It is not unusual for women to require more time for personal needs than men working under the same conditions. The allowance for the personal needs of the workman is frequently calculated so as to take care also of the regular oiling and care of the machine. This allowance is sometimes known as the "shop constant" because it is usually the same for all operations in the shop. It is ordinarily based on a percentage between 2 and 5 per cent of the selected operation time.

Delay allowances. Delay allowances include allowances for lost time due to occasional variations in material and interruptions by supervisors, and machine delay allowances for delays due to difficulties with machines or equipment, which may be outside the control of the operator. It is in the making of the delay allowances that the most care is needed, be-

cause, unless they are carefully set, they may be so large that all the previous care taken in making and working up the study may be wasted. All-day time studies provide a rational basis for calculating appropriate delay allowances. When conditions that modify the delays change, the delay allowance should be revised.

Fatigue allowances. The first factor in setting the fatigue allowances is the working conditions. If the shop is clean, well lighted, and well ventilated, they may be disregarded, as far as fatigue arising from general working conditions is concerned. If these conditions are not right and cannot be immediately made right, allowance must be made. The next factor is the length of the cycle of the operation. In general, the shorter the cycle, the greater the necessary fatigue allowance. The amount of physical exertion required must also be considered. If a job requires considerable physical exertion, the influence of the fatigue factor is large. On such jobs, however, the original study should extend over a large portion of a day, in order that the fatigue factor may directly influence the selected operation time. The presence or absence of stated rest periods should also be considered.

The study of fatigue. Physiologically speaking, fatigue is the result of poisonous waste matter in the system, and, since all labor produces this waste matter, to eliminate fatigue is to eliminate labor. There are two kinds of fatigue, normal and cumulative. Normal fatigue is weariness that is overcome by rest and need not be considered an industrial problem except for making due allowances in operating times; it may even be thought of as wholesome fatigue, which is similar to the pleasure derived from exertion in sports. Cumulative fatigue, resulting from overstrain, can be caused by too much work, too sustained work, or too monotonous work.

Signs of the presence of cumulative fatigue may be found in a study of production or accident records within an organization. If production tends to fall toward the end of the day or the end of the week, or if accidents seem to be unduly high at these times, it may be assumed that in the operations affected there is some cumulative fatigue which should be eliminated. The study of fatigue provides a fruitful field for industrial research. There is little evidence that modern industry, with persons working an 8-hour day, creates any cumulative fatigue that is harmful.

The influence of monotony is immeasurably greater than is ordinarily suspected. On the other hand, a number of operations frequently termed monotonous are far from objectionable to many persons. The attitude of the worker toward his job is largely controlling as far as monotony

is concerned. The following general principles may be stated with a fair measure of accuracy: [4]

1. Monotony is less likely to arise when the machine is entirely automatic.
2. Monotony tends to be reduced when the machine operation requires a high degree of concentration.
3. Monotony is most likely to occur when the machine operation requires the worker to be ever watchful, yet not enough care is necessary to keep his mind fully occupied.

Rest periods.[5] Fatigue elimination consists of improving equipment, as discussed under standard equipment; eliminating useless and tiring motions, as developed by job study; varying the job so as to relieve monotony; and providing rest periods.

Stated rest periods of 5, 10, or 15 minutes during the morning and the afternoon are particularly successful with women workers, especially if machinery can be stopped during these times.

Professor Ralph M. Barnes [6] has pointed out that rest periods are desirable in both light and heavy work for the following reasons:

1. Rest periods tend to increase the amount of work done in a day.
2. Rest periods are pleasing to the workers.
3. Rest periods tend to encourage the worker to maintain a level of performance nearer his maximum capacity.
4. Rest periods reduce physical fatigue.
5. Rest periods reduce the amount of personal time taken out during the day by the worker.

Total operation time. In the upper left of Fig. 19.2, p. 282, the time for each element is given. Assume that the worker was rated as follows from Table 20.1: skill A1, effort E2, working conditions E, and consistency F. This would give O as a leveling factor. The other data would be as follows:

	Operator	Machine	Total
Selected operation time	1.026	1.865	
Allowance factor	1.15	1.10	
Standard time (found by multiplying operation time by allowance factor)	1.180	2.052	3.232
Standard units per hour (60 ÷ 3.232)			18.6

[4] See Elton Mayo, *Human Problems of an Industrial Civilization,* The Macmillan Company, New York, 1933; also, H. M. Vernon, *Industrial Fatigue and Efficiency,* George Routledge & Sons, Ltd., London, for a detailed discussion of this subject.

[5] See Ralph M. Barnes, *Motion and Time Study,* John Wiley & Sons, New York, 1940, p. 140.

[6] *Ibid.,* p. 105.

CHAPTER 21

UTILIZING TIME-STUDY DATA

Setting standard rates for incentive pay. The actual setting of the rate may be in the hands of the rate-setting department, the superintendent or works manager, the personnel department, or a special wage and salary committee. The setting of the wage level is primarily the responsibility of top management. It may be delegated to the director of personnel with advice from the highest level of operating management. The basic function of the time-study engineer is to establish time standards for operations, not to place a price on the work. Nevertheless the time established for a given operation materially influences the earnings of workers who are paid by any system based wholly or partly on productivity. The fundamental consideration in rate setting is that a rate once set should never be cut by the management. Any other policy results in workers being hesitant to turn out maximum production for fear that the rate will be cut. Therefore, extreme care is necessary to insure that the rate is correct in the first instance.

A guarantee, usually placed on the instruction card which he receives, may be given the workman that the rate set will not be cut. The policy of the L. C. Smith and Corona Typewriters, Inc., is an excellent example of what plant policy should be in rate guarantees: Their printed guarantee goes to the workman along with his instruction card. The exact wording of the guarantee is not particularly important so long as it conveys the idea that management is acting in good faith and will not change the standard times unless conditions are materially changed.

Setting new rates by regrouping old elements. If accurate data are accumulated over a period of months and years regarding basic elemental times, they may be used in setting time standards for new jobs that are similar. In shops manufacturing diverse products, it is impractical to take time studies on many orders being manufactured, because of both the cost and the promise of early delivery dates. To be in a position to compile time standards from previous studies implies not only excellent studies to begin with, but also a well-worked-out filing system for the data that have been secured. Standard nomenclature of operations is also a great aid. Comparatively few elementary operations are per-

formed in most trades, but there are a great many combinations in which these few elementary operations may be performed. Nevertheless, great care must be exercised in reusing time-study data to insure that the element in question is in reality the same element studied previously, and that the conditions surrounding the new job are such that the information already secured may be freely utilized without injustice to either the workmen or the management. Many skilled time-study engineers contend that a standard time established from carefully proven standard elemental time values is more reliable than actual observation. The individual study may have errors that tend to be neutralized by many studies that have proven successful.[1]

Synthetic times and the use of elemental time values were discussed in detail in Chapter 20. In many instances a skilled estimator, supplied with accurate studies of similar jobs and cost data, can sit down in the office of his customer and give him a price on a new job that exists only in blueprint form. This practice is not uncommon among parts manufacturers that sell to larger manufacturers.

The instruction card. The distribution to the worker of instruction cards, carefully detailing the method of work on a job, as well as the time that the various elements should take, is an important follow-up of time-study work. The rate of pay is sometimes included on the instruction card. This device insures the utilization of the standard methods which have been established during the job study and gives each worker the best knowledge on methods of performance. It does not preclude innovations on the part of the worker, since he may recommend improvements, but it insures that any new methods which are used will be better than old ones and that they will be equally available to all workers on a particular task. Some incentive must be offered to the worker to suggest improvements; he may possibly be allowed personally to retain the full benefits of any new methods which he may discover; he may receive special recognition in the form of vacations, or he may be paid a cash reward for his suggestion.

Figures 21.1 and 21.2 illustrate two instruction cards, one for a machine operation and the other for a hand operation.

Instruction cards as an aid to methods. The instruction card is invaluable in crystallizing for future use the best method for the job that has been developed by the study. Full information concerning setup, tools, and methods of handling materials and tools is indispensable on instruction cards. If a worker, through his own initiative, can find a better way

[1] See H. Barrett Rogers, "Practical Analysis of Time Variables for Standard Time Data," *Proceedings of the National Time- and Motion-Study Clinic,* Industrial Management Society, Chicago, 1944, p. 21.

INSTRUCTION SHEET

Customer Amer. Tool Co.
Part No. 1073 A–F
Operation No. 5 TR.

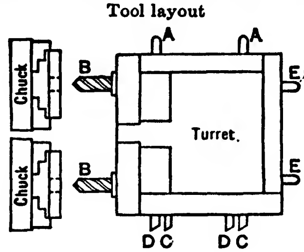
Part Name Spur gear Case D

Operation Name Drill, rough one side and ¾ of outside diameter

Dept. 11 Machine class, 58 Machine name, Jones & Lamson

Made by S. R. K. Approved by S. M. Date 7–9–35 Mat'l SAE2315

Tool layout



Set-up Time:
New set-up 60.00
Change of size 30.00

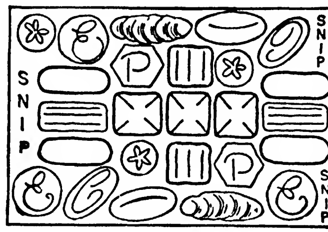
No.	Procedure	Tools—jigs, etc.	Speed Setting	Speed Ft./min.	Feed Setting	Feed In./rev.	Base time
1	Pick up and chuck 2 pieces						0.12
2	Start machine and true up (if necessary)						0.10
3	Change speed						0.03
4	Adv. turret and throw in feed						0.06
5	ROUGH OUTSIDE DIAMETER (¾)	A. ¾×1¼ in. tools		70	71	0.014	*2.32*
6	Back turret and index						0.07
7	Advance turret, set headstock, throw in feed and change speed						0.12
8	DRILL	B. 1 3/16 in. drills		60	71	0.014	*0.58*
9	Back turret and index						0.07
10	Advance turret and lock						0.08
11	Advance headstock, change speed and throw in feed						0.08
12	ROUGH FACE 1 SIDE	C. ¾×1¼ in. tools		70	71	0.014	*1.65*
13	ROUGH FACE HUB	D. ¾×1¼ in. tools		30	71	0.014	
14	Unlock, back and index turret						0.07
15	Advance turret and set head stock						0.09
16	CHAMFER INSIDE FLANGE	E. ¾×1¼ in. Form tools		70	Hand		0.10
17	Advance head stock						0.06
18	CHAMFER HUB	E. ¾×1¼ in. Form tools		30	Hand		0.10
19	Back turret and index						0.07
20	Set head stock						0.12
21	Stop machine						0.03
22	Loosen and remove 2 pieces						0.10
	Total handling time for two pieces						*1.47*
	Total machine time for two pieces						*4.55*
	Total base time for two pieces						*6.02*
	Total base time for one piece						*3.01*
	Allowances 10 per cent						*0.30*
	Standard time in minutes per piece						*3.31*

Courtesy, Ralph M. Barnes, "Motion and Time Study," John Wiley & Sons

FIG. 21.1. Instruction sheet for turret-lathe operation.

½ LB. BLUE RIBBON BOX (FLANGE) LIST No. 4623–12

Cups	*Unit No.*	*Name*	*Cups*	*Unit No.*	*Name*
Round	203	Raspberry Cup	Round	376	Caramelized Brazil
"	204	Apricot Cup	"	392	Croquante Whirl
"	221	Strawberry Creme	"	393	Vanilla Caramel
"	275	Coffee Creme	"	394	Marzipan Sandwich
"	371	Orange Marzipan	"	396	Tosca Pate



Heavy lines = Foil Covered Units

Make weight with Accommodation Units, one less than weight of last Chocolate.
If Light Add: 1 Croquante Whirl, 1 Apricot Cup.
If Heavy Take Out: 1 Apricot Cup.

	No.		*Patt. No.*	*Paper No.*
Linings (Center) (Emb. E. Foil)	1	13, $\frac{3}{8}$ × 6, $\frac{7}{8}$	Shaped	8795
" (Ends)	2	4, $\frac{7}{8}$ × 2, $\frac{15}{16}$	3226	8796
Top-Pad	1	6, $\frac{13}{16}$ × 4, $\frac{13}{16}$	....	4990
" Stock No. 04990—To be cleared first				
Cups (Round)	25	....	....	3569
Wrap	1	14, $\frac{13}{16}$ × 11, $\frac{1}{8}$	2716	142
Wrap fastened on bottom with Gloy, ends folded and fastened on bottom with Gloy.				
Printed Identification Key	1	8, $\frac{3}{4}$ × 6, $\frac{7}{8}$	....	5070

Snip—Brown.
Filled on Printed Identification.
Tear-off Price Seal (Stk. No. 2878) on wrap, top-left.

Foil (Stock No. 8666) Blue and Silver E. Design—to be used when Stk. No. 08666 is cleared.

FOILS

Stock No. 08666—Blue Printing on Silver.

Width of Reel 3″ for Tosca Pate, Marzipan Sandwich and Strawberry Creme.

Symbol No. F. 136.
Outer No. R. 976—Packed ¼ dozen.
Outer tied String—Single.

First packing to be sent to Inspection Office.
Issued to Inspection Office from New Lines Office.

New Lines Office,
January 14, 1937.

Courtesy, Ralph M. Barnes, "Motion and Time Study," John Wiley & Sons

FIG. 21.2. Instruction sheet for packing chocolates.

to do the job than that on the instruction card, every facility should be offered him to report this improvement to the methods or time-study department. This forms one of the logical reasons for a suggestion-reward system; such an improved method should be treated as a suggestion, and the job method changed. On new work which is not likely to be repeated, the instruction card forms a means of securing a profitable method from the first. On work which is repetitive, after the first few times that the operation is performed, the instruction card is less for the guidance of the worker as to method, since he is probably fully familiar with this, than it is for supervisors who may be checking up on the job from time to time.

Securing worker cooperation in checking time studies. When the instruction card with full data concerning time values for the respective operations is placed in the hands of the worker, it is a valuable aid in securing his approval or criticism. Giving the worker this information serves as an additional stimulus for the time-study department to be careful with its work. On the other hand, sharing the time-study results indicates to the worker that the time-study man is "square." When the worker has full information regarding the time allowed for each operation, he will naturally complain about any time allotment which he considers too short or unattainable. If it were always possible to use only the one workman who was time-studied for the particular job, all this precaution would be unnecessary; but, since this is impossible, full and hearty response from each workman must be insured.

Frequently a complaint is made by some operator that he is unable to reach the standard of performance called for on the instruction card. This may be due to one of the following causes or a combination of several of them: lack of skill on the part of the operator, trouble with his machine or equipment, delays which may have passed unobserved on the part of the time-study observer because they did not happen to occur while the study was being taken, an incorrect time study, or an attempt by the operator to secure a more liberal time by complaining. If an operator seems to be unable to make his standard time with any degree of regularity, and this situation is clearly not his fault on the face of conditions, it is essential that a new study be made to check the time study that has been taken, so that it may be finally determined whether or not the task time that has been set is fair.

Production studies. The new study that is made has been termed by some time-study men a "production study." The production study is similar to the all-day time study for allowances, but it seeks to check all factors concerning the work, whereas the all-day time study for allowances concentrates on one factor. The production study usually consists

of the observation of the operator during an entire day's time, or such part of the day as he is working on the operation concerning which he has made complaint.

During the observation of the worker in this production study a careful record is made of all times consumed, including a record of the element times in the same way that they were recorded when the time study was originally taken. The particular value of this type of study is twofold: first, an opportunity is given to check the operation at another time and therefore to see whether the delays that occur are practically the same and are caused in the same way as those noticed when the study was originally taken; and second, an opportunity is given to observe the effect of fatigue upon the worker, inasmuch as the study covers an entire day, which is an unusual length of time for an ordinary time study. A production study is, therefore, quite as much a fatigue study as it is a job study; in reality it consists of a combination of the two. It may conceivably happen that a time study which was accurate for jobs when they lasted only for several hours will prove to be absolutely incorrect for the same jobs when they are carried on for an entire day, because of the fatigue caused by performing the work for that length of time.

In order to insure accuracy in a production study, it is necessary that the element times be checked against the selected element times of the original time study. The observer will usually do this, to some extent, as he goes along, so that, if there are any great discrepancies, he will be enabled to see the cause during the time that he is taking the second study. On the other hand, much of the result of the production study can be secured only by working up the data at its conclusion. The charting of the times consumed during certain hours of the morning and the afternoon may give the necessary information concerning fatigue upon which to base recommendations of change in time allowed for the operation, or possibly on which to recommend relief from fatigue by means of rest periods.

Often interesting data obtained from the production study will in short order direct the attention of the observer to the causes of the workman's inability to make his standard time. For instance, if it should be found that the elements which are entirely handling time are being performed well within the selected element time, whereas the elements which are entirely machine time are running uniformly larger than the selected time, it is obvious that there is something wrong with the equipment or the method by which it is being used. At any rate the production study will clearly reveal whether a particular operator is unable to reach the time

that has been set because of the conditions of the time or the conditions of the job, including himself. It may reveal the fact that he is leaving his machine more frequently than is necessary, that he lacks skill, that the handling time and the time for the adjustment of the machine are unduly large, or that the equipment is in poor condition.

Studies of automatic machinery. Some people consider time studies of automatic machinery to be valueless. This would be true if the machines were kept busy all the time in productive work at the proper feeds and speeds for the particular job and if the most efficient use were being made of the operator's time. These two "if's" provide ample reason for making time studies of automatic machinery. As a matter of fact, such operations are among those of which it is most profitable to take time studies, and where the results achieved in proportion to the energy expended are likely to be large. Taking time studies of this type of job involves finding out the causes for delay rather than what the time of various elements should be. The times for the elements are involved in the continuous operation of the machine, which is also an important field of study for a methods department but does not necessarily involve time study.

It is impossible to operate automatic presses, screw-cutting machines, looms, or any other type of automatic machinery without interruptions; but a study of interruptions determines whether the worker or the machine is the cause of failure to reach the set task. Small automatic screw-machine shops have often proved a source of large profit to their owners on a small investment. On the other hand, similar shops have proved to be white elephants to other owners. The difference lies largely in whether or not the machines have been kept producing throughout the working day. In all automatic machinery, tools become dull or require changing, the material supply may run low, or there may be a number of other causes for stoppages. A time study of such machinery involves taking a production study for a period of a day or more to determine which of these stoppages are avoidable and which unavoidable.

To illustrate, a fine balance must be struck between making full use of the machine's time or the operator's. If the machine-hour cost is high in comparison to the operator's hourly earnings, it is more important to concentrate on keeping the machine busy even though the operator may have idle time. This statement of course does not hold without any qualifications. For instance, if the operator's rate is $1.50 per hour and he is kept busy only 28 minutes during the hour to keep a $3.00-an-hour machine operating 99 per cent of the time, it will pay to let the machine operate 90 per cent of the time, provided that the operator will be kept busy an additional 30 per cent of his time and assuming that production

requirements will stand this reduction. Each case has to be carefully worked out in terms of the particular situation.[2]

When the proper information is at hand, it is possible to set a rate of stoppages which will apply to a machine at all times when engaged on the class of work studied. This will enable the shop to set standard times on the automatic machines which will be entirely within reach, in the same way that they may be set on any other machines in the shop. The setting of the standard time merely involves taking the capacity of the machine and deducting the allowances which have been found by the production study to be necessary.

Securing worker acceptance of motion and time study. Some workers, particularly those in certain unions, have an antagonistic attitude toward time study. On the other hand, some unions have their own highly trained industrial engineers. In dealing with a group that is only lukewarm or even antagonistic toward motion and time study great care must be exercised. The situation is particularly difficult during periods of depression when many men are already out of work. An unwise move on the part of management during such times frequently precipitates conflicts that are more devastating than the inefficiencies corrected. One of the best methods of introducing time study in a plant that has never used it is by the "conference method." The program literally has to be sold both to the foremen and to the workers. A class in time and motion study in which both the foremen and the representatives of the workers seriously study the objectives and techniques of time and motion study prepares them both for its use. It is necessary for absolute honesty to prevail.

Time- and motion-study objectives should be clearly set forth:

1. To find the one best method of performing a task with due regard to the fatigue of the worker. The best method should be the easiest method.
2. To provide accurate information as an aid in planning and estimating costs of new jobs on which the company is quoting.
3. To serve as a basis for setting an equitable wage.

Management should recognize that the worker expects to share in the benefits of increased production. When standard times are once set, they should be rigidly adhered to unless conditions change fundamentally. A broken promise is long remembered. Full cooperation from workers cannot be expected unless a reputation for square dealing prevails.

[2] See Robert Lee Morrow, *Time Study and Motion Economy,* Ronald Press Company, New York, 1946, Chapter 22, for an interesting discussion of this subject; also L. P. Alford and J. R. Bangs, *Production Handbook,* Ronald Press Company, New York, 1944, p. 529, and *Factory Management and Maintenance,* Vol. 102, No. 12, December, 1944, p. 100.

PART VI

WAGE PAYMENT—BASIC RELATION OF EMPLOYER AND EMPLOYEE

CHAPTER 22

THE BASIS OF INDUSTRIAL WAGES

The power of wages. Wages play an important role in community life. This statement is true not only for the people who receive wages but also for persons who purchase products or services, because in the ultimate analysis a large portion of costs is derived from wage payments. Ordinarily, the scale of living of the worker is, at any given time, directly dependent upon the amount and the purchasing power of the wage which he is receiving. Usually he has no accumulated surplus upon which to draw and no sources of income other than his daily wage. Therefore, the wage that is paid places or lifts restrictions on the home life and recreation of the worker and affects his personal life in a way unknown to any other factor of management.

The higher the wages that are paid, *up to a given point of maximum return,* the more effectively the organization will operate. The smaller the amount of wages that is allowed to flow through the economic organization, the less balanced and effective it becomes. Wages paid cannot be considered in the absolute but must be considered in relation to those paid by other companies in the same field of business or in the same community, and in relation to the economic needs of the workers as well as the goods and services available to be purchased.

Real wages. In discussing wages it is important to distinguish clearly between *real wages* and *monetary wages,* particularly when comparing wages of one period or one locality with those of another. From the standpoint of the worker, or his standard of living, the real wage is the vital factor. The real wage is measured by the goods and services that can be purchased with the monetary wage. The monetary wage is represented by the actual monetary units that the individual receives. A worker who receives $54 per week and has to pay $60 per month house rent with other living costs proportionate is in a relatively worse posi-

tion than another worker who receives only $38 per week and pays $30 a month for house rent with other living costs correspondingly low.

Merely to increase wages without increasing the output usually means that prices rise, that money is worth less (inflation), that persons such as aged pensioners, widows, or others who have a fixed monetary income have a lower standard of living, and that the workers receiving the increase are relatively little, if any, better off than before wages were raised. Of course, raising wages for one group may in fact improve the standard of living of this group by giving it a larger share of the total goods to be distributed. It is unfortunate that the great mass of our population does not understand the relationship of the wage level to the standard of living.

The satisfactory wage. Determination of the amount of wages paid under our industrial system has rested primarily with the employer during the past 50 years, especially before the general acceptance of collective bargaining. The wage, nevertheless, had to be satisfactory to the employee and was limited by its acceptability to the workers individually and collectively, at times by the general attitude of the community, and possibly by some governmental or state action.[1] Thus, instead of a basic wage which is set entirely by the employer, there is found a basic wage which is ordinarily termed "right" or "satisfactory." There can be no general definition of the meaning of a satisfactory wage, inasmuch as its limits differ so greatly under varying conditions. However, it can be stated that a satisfactory wage must bear the scrutiny of employees and, at times, of the community. The general attitude of the community is not likely to affect an individual plant unless the plant is the main or basic industry of the community, or unless, as in a localized industry, a large portion of the community other than those who actually work in the plant secure their livelihood as a result of the wages paid within the factory.

In the final analysis a wage that is as high as the prevailing wage in the community for a given classification of work or one that will enable the employees to maintain the standard of living to which they are accustomed, whichever is higher, may reasonably be called a satisfactory wage.

Not infrequently satisfactory wages are spoken of as though they were "fair" wages. In order to indicate the inaccuracy of such an idea and also to prevent confusion when a so-called fair wage is attacked by the

[1] The Fair Labor Standards Act was passed by Congress and signed by the President, June 25, 1938. This Act attempts to establish minimum wages and maximum hours for industries engaging in interstate commerce. Several of the individual states have similar laws.

employees, it will be well to examine the fundamentals of what constitutes fair wages.

What are fair wages? Any valid conception of fair wages must necessarily include the idea of payment to wage-earners on the basis of their contribution [2] to industry, as well as some concept concerning the right to a fair living for an individual engaged in the productive process. The productivity of an individual has never been satisfactorily measured under our present industrial system. Life is so complex, and the relations of one person to production are so inexact, that it becomes practically impossible to determine the extent to which he has added to the goods of the world. Before the introduction of the factory system it was more nearly possible to arrive at some concept of the productivity of an individual, but the factory worker of today performs but a small part of the production of an article. The machine on which he works and the building in which he works not only have been designed and furnished by the employer and the management, but also have in the first instance been created by other workers. A weaver working on a loom contributes much to production of the finished product which comes off the machine. The question remains, How much of his production is made possible by the workers in another factory far removed who made the loom? The economic theory of marginal productivity is helpful in theoretical discussions, but it is difficult to apply on a large scale to changing industrial conditions. Our idea of justice in the abstract must be tempered by practical considerations in its application to social conditions.[3]

Presumably, regardless of the productivity of the individual, there is a point below which wages must not go if the individual and the persons dependent on him may survive. This point is seemingly the lower limit of a fair wage, but in particular cases even this lower limit must presumably be passed if the worker is to be paid according to his productivity and not according to his need. Even the most communistic minded would scarcely expect a private employer to pay a janitor with fourteen relatively young children a wage high enough to provide them with the standard of living that most people would like to see them have. There

[2] This concept is not universally held by students of ethics or economics. The communistic philosophy has frequently been expressed: "To each man according to his needs, and from each man according to his capacity." More recently in Russia it seems for practical purposes to be, "To each man according to his performance, and from each man according to his capacity." (See Z. Clark Dickinson, in *Compensating Industrial Effort,* Ronald Press Company, New York, 1937, pp. 65, 84, 134 n.)

[3] See Frank C. Sharp and Philip G. Fox, *Business Ethics,* D. Appleton-Century Company, New York, 1937, pp. 181–194, for an interesting discussion of the ethics of a fair wage.

may be some logic in a large governmental unit's underwriting large families, but this is an entirely different matter from a private employer's paying different wages to men doing the same kind of work, merely because one has a larger family than the other.

Measurements which aid in the consideration of the equity of a wage. Two measurements are available which aid in the determination of this approach to equity in wage payments. The first is that the wage must represent the results of an honest effort to divide the product of industry on a reasonable basis. The wage which is paid because the employment manager calls up a manufacturers' association on the telephone to find out from the secretary what is being paid for a given class of job at a given time does not represent any such effort. It is desirable to know the prevailing wage in the community, but this alone is not enough, especially if the employer is in a position to pay more and the standard of living of his employees is lower than is desirable.

The second measurement is that the wage must command the support of all groups connected with the industry and of the community at large. If it does, presumably the wage is approaching an equitable wage. Because of all the factors which have been described, however, it is better to think of the proper basic wage in industrial plants as being a satisfactory wage, rather than a just, fair, or equitable wage.

The bases of satisfactory wages. There are three main bases frequently referred to as primary in wage determination: *supply and demand, cost of living,* and *individual productive capacity.* It is probable that in most instances all three aid in the determination of the basic wage rate, but no single one alone sets this rate. Supply of and demand for a given type of labor unquestionably have a large influence on the wage paid in most plants in the moderately long run. The workers, through organized labor and its attendant policies of the closed shop, restriction of apprentices, and elimination of overtime work, have sought to limit the supply of workers. As either the employer or the employee gains the upper hand in connection with demand and supply for workers, wage rates are seen to fluctuate. This does not imply that rates are reduced immediately when the labor supply exceeds the demand and the unemployed worker would be glad to secure employment at a lower wage. The "going rate" in a community tends to be perpetuated for some time after a reduction in the demand for labor.

In the long run wage rates tend to be set largely on the basis for which the worker can be secured, that is, what he can get elsewhere in the same community. Large organizations having plants in different cities pay different wages in each plant for the same work, depending upon the wage levels in these communities.

The General Motors Corporation's union contract of April 16, 1945, recognizes this situation as follows:

> The establishment of wage scales for each operation is necessarily a matter for local negotiation and agreement between the Plant Managements and the Shop Committees, on the basis of the local circumstances affecting each operation, giving consideration to the relevant factors of productivity, continuity of employment, the general level of wages in the community, and the wages paid by competitors.

Although supply and demand for labor have a direct, moderately short-run effect upon wages, good management makes no attempt to follow *closely* the ups and downs in the labor supply with wage changes.

Characteristics of a satisfactory wage plan. Enlightened leaders of workers as well as scientific representatives of management recognize that wages should possess certain rather fundamental characteristics if the long-run interests of both, as well as that of the consumer, are best to be served. In summary form these characteristics are as follows:

1. It is desirable that the worker be given a guaranteed minimum wage to protect him against conditions over which he has no control. (This does not mean a guaranteed annual wage, although this is desirable where economically feasible, but a guaranteed minimum wage for the days when he works.)
2. Base wages for each job classification or skill should be related to each other in terms of job requirements, due consideration being given to such factors as skill, length of time required in learning, versatility required, working conditions. Wage levels in different communities may vary, but the different skilled jobs tend to bear the same general relationships to the common labor rate in each community. Figure 22.1 shows the trend of common labor rates.
3. Within a given classification or skill, wages for different workers should be primarily in terms of "output." Motion- and time-study techniques should be used in establishing standards that may reasonably be expected.
4. The wage plan should be easily related to cost controls and the operating labor budget.
5. The wage plan should facilitate the comparison of relative efficiencies of various departments or operating units.
6. The wage plan should make adequate provision for learners. (Experienced workers should not absorb the cost of teaching beginners.)
7. The wage plan should be simple and easily understood by the workers.
8. The wage plan should not involve excessive clerical costs.
9. The wage plan should be flexible in order to meet changing conditions.

Wages in relation to the cost of living. One of the common reasons given by workers in demanding a general increase in wages is the cost of living. During periods of rapidly rising prices and an acute labor shortage, such as that in the early stages of World War II, union contracts often contain an escalator clause which provides that, if the cost of liv-

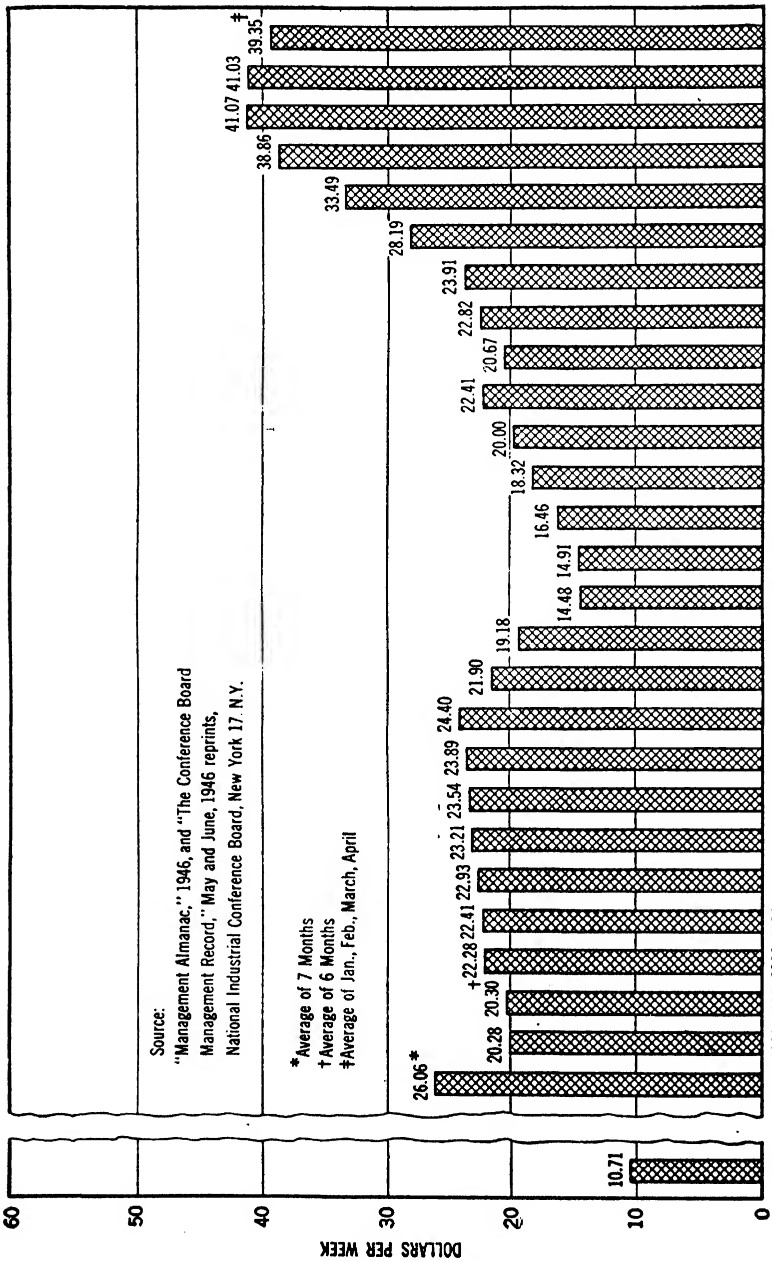


FIG. 22.1. Average weekly earnings of unskilled male production workers in twenty-five manufacturing industries. (Includes overtime and other monetary compensation.)

ing, as manifested by the Bureau of Labor Statistics Cost of Living Index, rises some amount, such as 5 points, wages will automatically be increased by some fixed amount, such as 5 cents per hour or sometimes 5 per cent. It should be noted that organized labor almost invariably insists upon this provision being one-sided—wages may rise, but not fall. Many of the plans using an escalator clause provide that changes may be made only at stated intervals. This is particularly desirable when the plan provides for a fluctuation for each change of 1 or 2 points of the Bureau of Labor Statistics Index.[4]

Although cost-of-living figures are adequate as a check on base rates, one of the most unsatisfactory features of them is that they are ordinarily based on the "average family." This usually consists of a man and wife and two or three children. The position of the single man or the man with seven children is thus thrown into question, if these cost-of-living figures are extensively utilized. A number of plants utilize figures of the Bureau of Labor Statistics, Department of Labor, of the United States government.

Although it is desirable to increase wages to meet the rise in the cost of living, and in general either wages should rise with increased productivity of labor or the cost of the product should be lowered to the consumer, it is also true that there is strong argument for lowering wages when the cost of living drops. This does not mean a frozen standard of living, but rather an intelligent recognition of the relationship among wages, costs, and the price of goods which is primarily controlling in the cost of living.

The Philadelphia Rapid Transit Company for years successfully operated a wage plan that was directly related to the community cost of living. Their index was known as the Market Basket Index. The unsettled conditions arising from the outbreak of war in Europe and previous interpretations of the legality of collective bargaining under the then-existing Cooperative Plan (1938) led the company to discontinue the Market Basket Index as of December 31, 1939. The system used was quite simple. The arithmetical average of the prices charged for commodities in the local stores was weighted by given quantities. The resultant costs were compared with the costs of the same or similar commodities in the base year 1925, and an index number for each group was thus obtained. The percentage change was, in turn, weighted by the group weight, and the sum of these changes determined the Market Basket Index.

[4] See the Conference Board Management Record, November, 1941, for a survey of the use of the cost-of-living adjustment plans.

Any intention of using the cost of living as a basis of industrial wages must include a willingness to increase wages as the scale of living increases, if the wage scale is to be successful. There is no outstanding difficulty in recognizing the fact that the wage level must rise in conformity with a general rise in the standard of living. As a matter of fact, living standards rise very gradually and not by sudden spurts. The entire program requires mutual confidence on the part of both men and management.

Productivity as a basis for wages. As a matter of basic principle it would be desirable to pay workers in proportion to their relative contributions to the product. In actual practice this cannot be carried out in minute detail. Individual productive capacity cannot serve wholly as the basis for setting wage levels. Productivity can be viewed as a partial aid in determining relative wage rates, and all of the work in job study and in the development of particular wage-payment systems which has been carried on in industry has had this end in view. If an engineer is employed, it is to be presumed that he will be paid at a higher rate than a laborer in the shop. This difference is due not entirely to supply and demand, but partly to the concept of individual productive capacity. This factor, therefore, influences very largely all wage rates which are set, but any thought that it governs them entirely must rest on the basis that the exact contribution of wage-earners can be measured. It has been demonstrated that this is difficult, if not impossible. The influence of individual productive capacity not only is felt on original rates granted members of a working force, but also has an even greater influence on changes which are made in these rates after employment.

Payment of wages above the community level. Large numbers of employers in many areas insist that their wage policy is to pay a somewhat higher wage than that prevailing in the community. From the very nature of the situation it is *impossible for the average employer to pay more than the average.* A more accurate statement of the wage philosophy held by large segments of modern managers would be that they desire to pay a wage as high as the prevailing community wage or in some cases higher than this rate. All industries are not in so favorable a position to pay high wages as the automotive industry has been. The lesson learned from this industry has been applied throughout the United States, and everywhere today there is less tendency to economize by reducing wage levels than there was 20 years ago.

That high wages do not necessarily mean high labor costs, but, properly utilized, may mean low labor costs, is well understood by modern industrial managers. "High wages and low unit costs" was the central

theme of Taylor's *Differential Piece Rate Plan.* The policy of most organizations with modern management involves the payment of higher wages than would be paid under the older types of management. This higher wage may be returned through the lowering of overhead costs because of increased production and other benefits that are secured through complete cooperation between the management and the workers. If this is the goal, together with a recognition of the importance of wages as a factor in industrial management, the question of exactly how wage levels should be set decreases in importance.

The sliding scale. Under this scheme a basic rate is fixed to correspond with a determined selling price of some finished product of the industry, and then, with fluctuations of the selling prices, rates drop or advance a predetermined amount. This method of wage payment finds little use in the United States, although it is considerably more popular in Europe, particularly in England. It generally works to best advantage in negotiations between bodies of employers and unions, since it involves the acceptance of the plan on the part of employees; this is difficult to obtain except where they are organized. In certain regions of the British mining country the coal miners have had wide experience with sliding scales of wages based upon the selling price of coal. In 1921 the sliding scale of wages was tied not only to the selling price of coal but also to the average profit margin in the district.[5] Some careful students of the subject are of the opinion that such a program results in somewhat steadier employment.[6]

The method of determining the way in which the scale of pay will fluctuate with the scale of selling prices is a matter for bargaining, but ordinarily the increase or decrease of the wage should bear approximately the same relationship to the increase or decrease of the selling price that wages bear to cost of production in the particular industry or plant.

A formal sliding scale, adopted in advance, will not succeed unless the commodity being manufactured has a wide, competitive market, with open quotations on current selling prices. Thus the sliding scale may easily be introduced into the manufacture of pig-iron because quotations on finished pig-iron are easily ascertainable.[7] It may be introduced into

[5] See Z. Clark Dickinson, *Compensating Industrial Effort,* Ronald Press, New York, 1937, pp. 345, 350.

[6] James A. Bowie, *Economic Journal,* Vol. 37, September, 1927, pp. 384–393.

[7] The Anaconda Copper Mining Company's union contract of September 18, 1939, made the following provisions:

> The minimum wage for an eight-hour day payable to journeymen shall be five and 75/100 dollars ($5.75), provided that where the differentials in amount of rates

cotton-spinning, because its fluctuations may readily be based on the selling price of a particular grade of cotton yarn. The sliding scale is not, however, applicable to a specialty business.

of pay for journeymen because of classifications were, on July 1, 1939, higher than said minimum, the said differentials shall not be changed in amount.

The minimum payable to helpers shall be the minimum payable to journeymen less seventy-five cents (75¢) per day.

The said minimums are based upon a price for electrolytic copper of less than nine cents (9¢) per pound.

When the price of electrolytic copper is or exceeds nine cents (9¢) per pound and continues for a period of thirty successive days at or exceeding an average of nine cents (9¢) per pound, the said minimums shall be increased twenty-five cents (25¢) per day; when the price of electrolytic copper is or exceeds nine and three-fourths cents (9¾¢) per pound and continues for a period of thirty successive days at or exceeding an average of nine and three-fourths cents (9¾¢) per pound, there shall be a further increase in the wage of fifty cents (50¢) per day; when the price of electrolytic copper is or exceeds eleven and one-half cents (11½¢) per pound and continues for a period of thirty successive days at or exceeding an average of eleven and one-half cents (11½¢) per pound, there shall be a further increase in said wage of twenty-five cents (25¢) per day; and when the price of electrolytic copper is or exceeds thirteen cents (13¢) per pound and continues for a period of thirty successive days at or exceeding an average of thirteen cents (13¢) per pound, there shall be a further increase in said wage of twenty-five cents (25¢) per day, and similar increases of twenty-five cents (25¢) per day shall be made for each one and one-half cents (1½¢) of rise in the average price of electrolytic copper for any period of thirty successive days above thirteen cents (13¢) per pound, subject to the conditions hereinafter provided.

There shall be no increase in the said wage until and unless the price for electrolytic copper reaches a base price at which an increase in the then current wage is to be made under the foregoing schedule and until and unless the average price of electrolytic copper for a period of thirty successive days thereafter equals or exceeds such base price, and in such event such change shall remain in effect for a continuous period of not less than thirty successive days. In case the price of electrolytic copper declines below the base price upon which the then current wages are based and the average price of electrolytic copper for any period of thirty successive days thereafter is less than such base price, the wage to be paid after said thirty-day period shall be the minimum wage above set forth plus such addition, if any, to such minimum wage, as the schedule above set forth provides shall be made with respect to such average price. Further successive increases or decreases in wage shall be made subject to the foregoing conditions, dependent upon the average price of copper from time to time; provided, however, that when a change in wage is made, no further change therein shall be made for a period of at least thirty successive days.

The price for electrolytic copper on any day shall be that quoted for such day in the *Engineering and Mining Journal* for deliveries F.O.B. Connecticut Valley points, and the average price per pound of electrolytic copper for a period of thirty successive days shall be the average of the prices for said thirty days set forth in said *Journal* for said deliveries.

Some employers have what is variously called a *wage-bonus, wage-dividend,* and *profit-sharing* plan, which is related to one aspect of the sliding scale, namely, increases. General Electric, Eastman Kodak, Lincoln Electric, and other companies have used such plans. If the volume of business and profits justify, the employees are given some form of an increase in earnings, the amount being usually related to their base earnings.

CHAPTER 23

WAGE-PAYMENT PLANS NOT BASED ON CAREFULLY ESTABLISHED STANDARDS

The approach. Wage-payment systems are discussed in this chapter from the standpoint of management, that is, with the aim of securing the maximum production from the worker compatible with his health and fullest cooperation. In treating this subject, there is no necessary conflict between this viewpoint and the standpoint of the worker or the welfare of the community. Actually in the long run these interests are mutual. If we approached the wage discussion from another angle than management, our emphasis would be somewhat different, but the results would inevitably be the same.

In considering wage-payment systems it is well to keep in mind the requirements of the cost-accounting department of the business as well as of the production and general-management forces. Systems which involve the collection of a multiplicity of data may conceivably succeed in increasing output and thus decreasing the unit labor cost, but may fail because of the excessive cost and difficulty of collecting data for payroll and cost purposes.

The day rate. Payment by the so-called *day rate* is primarily payment on a *time basis* which includes the hourly, daily, and weekly systems. Of course it is recognized that *all incentive systems,* including straight piece work, *are related in their initial conception to time,* since they presume a given quantity of work for the expected average earnings within a specified work period.

The day rate is perhaps the oldest method of wage payment under our present industrial system, and a large proportion of the industrial workers of the United States are today being paid under some form of the day-rate system. Unless the worker is so inefficient as to merit discharge or so expert as to be raised into a higher wage classification, it is unlikely that his individual rate will be changed. Thus the amount or quality of work which he does has little bearing on the wage which he receives, except over long periods of time. Under the straight day rate there is little to urge a worker toward greater production except loyalty to his task or some spurring action on the part of his employer or his direct superior.

Many workers have favored the day rate, because under it they can definitely determine in advance what their wages will be. That all workers of a given class generally receive the same pay constitutes no objection for some workers. In fact, they tend to approve this situation, because it encourages a unity of action, through union organization, of all members of the wage group, if it seems possible to secure an increase in the rate. For these reasons day rates, once raised, are frequently as difficult to lower as any other kind.[1]

In the main, labor unions have tended to favor the day-rate system. Unions exist for the benefit of their membership as a whole, and therefore anything which will tend to increase the unity of purpose of their members is likely to enlist their support. The day rate is a perpetual influence toward solidarity in the union. Substandard workers look to it as a means of raising their wages far beyond anything they could expect under a system based on merit or output. The average worker is likely to be satisfied with the prevailing wage. The best workers are likely to be striving constantly to increase their incomes and in doing so will tend to increase, along with their own incomes, those of the other members of the labor group. The best workers, who, under other systems of payment, are least likely to be interested in unions, under the day rate are likely to be the prime movers toward organization. It is their only hope for increased wages. Thus they frequently begin to combat the management, whereas under other circumstances they may be made management's greatest supporters.

It must not be inferred that all unions oppose piece rates or other wage programs based on output per worker. During World War II, when wages were largely frozen, some unions turned to some form of incentive system based on output as their only method of securing an increase in income. For more than thirty-five years the men's garment workers in Chicago have been operating on some form of incentive wage payment which pays for productivity per worker. This is one of the most highly organized and disciplined groups in the union movement.

Quality of product may be enhanced through the day rate. The workman, not being rushed, should be able to utilize his talent fully in those tasks where such expression is possible. Plants or departments in which quality is a paramount consideration are thus most likely to be on day rates. Nevertheless, effective foremanship and newer methods of wage payment make possible high-quality production without the day rate.

[1] The student should keep in mind that day rate, as used here, refers to a system in which accurate standards have not been set. It is possible to have a system of time payments based on job study with carefully set standards of performance. The objection cited above does not hold under such measured performance.

Payroll-department operation is made simple by the day rate. The payroll may be prepared directly from the attendance time cards. On the other hand, *cost-department operation is made more difficult.* Production will vary greatly from man to man and from day to day under this system, and wages become a variable element of cost which cannot be predetermined. Thus it becomes difficult to plan production-cost budgets and to set selling prices in relation to costs.

Regardless of the type of wage-payment system that may be in use, it is usually necessary to compensate a certain percentage of the workmen by the day rate. This group of workmen includes not only supervisors, but also men whose work is so diversified, incapable of standardization, or temporary as to make it impossible or impracticable to work out a satisfactory wage under any other system of payment. Because of its ease of operation the day rate will probably continue to be much used as a system of wage payment.

The hour, rather than the day, may be used as the time unit. In this case the worker's earnings are computed as follows:

$$E = RN$$

in which R signifies the rate per hour and N the number of hours worked. This usage of the term "day rate" is inaccurate but has become quite generally accepted.

Use of incentive plans. Certain types of manufacturing industries have had a wide experience with various incentive systems. The trend has been definitely away from the complicated systems that involve a great deal of clerical work and are difficult for the worker to understand. The various needle trades, rubber industry, machine shops, and various standardized types of industry use straight piece work, the standard hour, and some type of bonus plan most extensively. In metal-working and the needle trades piece rates are still the most popular, followed by the standard hour and some form of bonus plan.

The statement that there is a trend toward simpler forms of wage payment should not be interpreted to mean that the Bedaux and similar systems are no longer in use. Quite the contrary is true. The Bedaux is one of the popular systems, partly because of its inherent merit when considered along with the efficient management techniques that accompany the wage plan and partly because of the aggressive promotion of an able management-consulting firm.

Incentive plans are used in practically all types of industries—mass-production and semi-mass-production enterprises and job shops. Although the various incentive plans are utilized more frequently on direct

labor jobs, they are also used for maintenance men, truckers, packers, stockmen, and crane men.

Table 23.1 illustrates the distribution of the use of various wage systems for hourly rated workers, as found in a survey made by the National Industrial Conference Board, Inc. Table 23.2 shows the distribution among the various plans of workers receiving incentives.

TABLE 23.1

DISTRIBUTION OF HOURLY RATED WORKERS IN 313 COMPANIES USING WAGE INCENTIVES *

Method of Payment	Number of Hourly Rated Workers	Percentage of Coverage
		Nonincentive
1. Straight time rates	143,993	38.2
		Incentive
2. Individual piece rates	112,977	61.6
3. Group piece rates and tonnage rates	27,005	
4. Individual premium and bonus rates	41,031	
5. Group premium and bonus rates	30,613	
6. Measured daywork (individual and group)	20,312	
		Mixed
7. Other (mixed)	902	0.2
Total	376,833	100

* Source: National Industrial Conference Board, Inc., *Studies in Personnel Policy, No. 19*, p. 10.

TABLE 23.2

DISTRIBUTION OF WORKERS IN 313 COMPANIES UNDER THREE MAIN METHODS OF WAGE-INCENTIVE PAYMENT *

Class	General Type of Incentive Payment	Number of Workers	Percentage of Total Workers
Piece work	Individual rates	112,977	48.7
	Group rates	27,005	11.6
Premium and bonus	Individual rates	41,031	17.7
	Group rates	30,613	13.2
Measured daywork	Individual and group rates	20,312	8.8
Total		231,938	100.0

* Source: National Industrial Conference Board, Inc., *Studies in Personnel Policy No. 19*, p. 10.

Piece rates not based on carefully established standards. Under straight piece rate without job study the task may be either the completion of one unit or of a given amount of work, and the rate is ordinarily termed a piece rate. Piece rates have usually been set with strict regard to previous day-rate earnings and previous performance. They have usually been determined by dividing the day rate by the average units of production in order to secure the proper rate per unit. Frequently the rate has been made somewhat less than this amount, on the assumption that production will increase under piece rates and thus the unit labor cost will be lowered. In the early days many employers were willing, at the start, to profit only through the reduction in their fixed overhead expenses.

First-class workers on repetitive jobs have usually been anxious to be placed upon piece work, inasmuch as it gives them an opportunity to profit from their accumulated skill and knowledge of the job. The prospect of direct monetary gain is likely to result in the worker's studying the method of performing his job. Within limits he becomes receptive to improvements in methods promulgated by the management. He is not receptive to such improvements, however, when he is fearful that they will be so made as to result in cutting the rate.

It is difficult for many workers to realize that basically, under any logical payment system, they should be paid for *the work that they do,* and that, when management makes improvements, they may often produce as much as 1.3 times the former number of pieces with no increase in actual work on their part. One objection to any form of piece rate is the fact that workers tend to think of such rates as being *fixed* in relation to the pieces themselves and that they should never be changed (except upwards). Such an attitude, if permitted to be controlling, will naturally stand in the way of progress. Management, of course, is at times to blame for this attitude, either because of undue emphasis on the piece rate, rather than the amount of work involved in producing the piece, or because of making changes of no significance merely to alter rates.

Substandard workers and those on diversified jobs on which the setting of piece rates based on past performance is difficult are not likely to favor piece rates. This is a perfectly natural attitude, since the substandard worker will have to exert himself more to earn his normal day rate; also diversified work does not lend itself so readily as repetitive work to piece rates.

Cutting rates. When piece rates are set on the basis of past nonstandardized performance, it is common for the workers to be able to

increase their output by 50 per cent. Although the employer is receiving benefits in reduced overhead charges, he is not likely to allow workers to continue for any great length of time to "kill" a job, that is, to get wages which are far in excess of those usual for such work. The pressure of competition, the desire for increased profits, or both are likely to cause the employer to demand that management cut the rates. The action of rate cutting is equivalent to informing the employees that there is a maximum of earnings beyond which workers of any general class will not be permitted to go. Such action, once taken in an organization, or fear of such action based on practices in other organizations, causes workers to hold their production under piece rates at the easily attainable figure which it is thought the employer has set as his maximum. If rates have once been cut, this figure will at times be so uniform throughout a shop as to amount almost to an exact limit.

Changes in method have at times been bitterly fought by workers for fear that under the new method and new rate they would be unable to make as high piece-rate earnings as under the old method. Really radical modifications in production method, which so change the job as to make the past rate absurd, have been frequently regarded by workers merely as *an excuse for cutting rates.* This confusion between logical piece-rate readjustments and rate cutting results in numerous borderline cases which it is difficult to settle amicably because there are no real data, convincing to both sides, which may be used as a basis.

Inasmuch as no day rate is guaranteed under straight piece-rate plans,[2] it is necessary that a special "learner's rate" be established, which is usually on the day-rate basis. The length of time that the learner remains on day work varies with the type of operation and with the factory, as well as with the training system that the plant has installed. The learner's rate usually starts at a low point and gradually increases up to the point at which the worker is put on piece rate. Another method of providing for the learner is to pay a flat day rate, such as fifty cents per hour for a short period, and then reduce the day rate during successive periods, allowing the learner the lowered day rate plus his earnings on pieces completed at the regular piece rate. Such a program provides a strong incentive for the beginner to make a special effort to increase his speed of learning. In the absence of some such sliding day-rate scale, it is not at all infrequent for a beginner to work the full learning period on the day rate and then refuse to go on piece work, giving as his reason that he cannot make out on piece work.

[2] Of course, there can be a piece-rate plan with a guaranteed minimum day rate

Difficulty in the setting of piece rates is encountered when the whole level of rates paid workers rises and falls. Piece rates have the disadvantage of being somewhat inflexible. If rates have been raised during periods of high wages, they are usually decreased during periods of depression and falling wages. Such lowering of wages is, of course, a cutting of the piece rate. This situation results in very perplexing problems which have been solved by some plants not by increasing piece rates, but rather by giving a "cost of living" bonus, or, if the rates are increased, by placing the wages from the increased piece rate in a separate pay envelope.

In times of depression, when orders are scarce, the piece rate has an advantage over day rates or any of the other systems which guarantee minimum earnings to the worker. Under such conditions many plants are operating from hand to mouth on orders, and this situation is as well known to the workers as to the management. The piece rate does not invite the employee to stretch available work so as to insure himself a job under such conditions. In prosperous times, with orders plentiful, this advantage of the piece rate ceases to exist.

From the cost-accounting and cost-estimating standpoints, piece rates are far better than day rates, but are not ideal, as contrasted with some other systems. The direct labor cost per unit of product or per job becomes a fixed amount, which may be accurately determined in advance. But, since the time of doing the work varies considerably, the amount of overhead expense which will have to be distributed to an operation or an order is an unknown quantity before actual performance. This same criticism holds with equal force for most of the other incentive plans.

The computation of earnings on the piece-rate system is very simple. Expressed in terms of a formula, earnings = the number of pieces times the rate per piece, or $E = NR$. If the rate per piece is 15 cents and the worker completes 48 pieces in a given day, his earnings will be: $48 \times \$0.15 = \$7.20$.

Incentive wage systems. Schemes can be devised which will prove entirely satisfactory to the worker but which will in time be eliminated by those controlling the enterprise because they are not flexible enough to permit the meeting of increasing sales competition. Thus any wage scheme which gives the worker a percentage of the savings incident to increased production and yet prohibits innovations in manufacturing method or merely inclines the worker to peg his production at a somewhat higher point than formerly, because of fear of ultimate wage cutting, will not be beneficial for long. Rival plants, whose rates are set on the basis of newer manufacturing methods, or whose workers have not

pegged production even at the relatively high level, will always be able to underbid because of lower manufacturing costs. This is the basic reason behind changes of rates when the process or operation is changed. It is essential that any wage-payment system which is devised so arrange the remuneration that the permanent cooperation of both the workers and the management will be assured.

In general, it may be definitely stated that unorganized employees and some organized employees like to work under one of the incentive wage systems when they are fully convinced of the fairness of the management and the fullness of information possessed by the rate setters, as well as of their competence. These systems plainly indicate to the workers that they are expected to perform up to their capacity, with due regard for health, safety, and avoidance of fatigue. *Incentive wage systems awaken interest and inject the spirit of competition into industry.*

An incentive wage, in order to be effective, *must generously reward the worker for the additional application, following of instructions, increase in output, and quality of workmanship which is required to earn the additional wage.* In Taylor's experiments he found that increased effort on the part of certain classes of workers could be stimulated only by paying incentives above the base rate as follows: [3]

	Percentage
Machine-shop workers doing general work	30
Laborers performing work calling for severe bodily exertion	50–60
Machinists doing delicate and difficult work	70–80
Machinists performing work requiring close application, strength, skill, and brains	100

It should be emphasized that cupidity on the part of management is equivalent to signing the death warrant of any of these incentive schemes of wage payment. If the reward is large enough, the worker will be enabled to take new pride in his job. The pride of accomplishment in relation to his fellow-worker develops. This is a perfectly logical and justifiable pride, and there is no evidence to show that it results in the setting of a killing pace.

Symbols used in wage formulas. The formula for computing earnings for piece rate was given as follows: $E = NR$, in which E represents the earnings per day or period, R signifies rate per piece, and N stands for the number of pieces produced. R is used in other wage plans to indicate the rate per day or whatever other unit is used as a basis for payment. Other symbols that will be used are as follows:

[3] See Frederick W. Taylor, *Shop Management,* Harper and Brothers, New York, 1919, p. 26.

S = standard or allowed time for completing a particular task. To illustrate, if the standard for a given piece of work is 10 minutes and a worker completes 6 pieces, his S, standard or allowed time, would be 1 hour, even though the actual time worked may have been 50 minutes or even 70 minutes.

T = actual time spent in performing a given task.

p = premium percentage.

The Halsey premium plan. The Halsey premium plan was devised by F. A. Halsey at the time that he was superintendent of the Rand Drill Company of Sherbrooke, Canada. The Halsey plan sets a standard time, usually by ascertaining the average previous time of doing the job, and offers the workman an agreed percentage of the wages of any portion of this time that he may save, in *addition to his hourly or daily rate for the time consumed on the job.*

Although, as originally conceived and generally used, the standard time under this plan is the standard of past performance in the shop, there is no reason why a standard time determined from time study cannot be used under the Halsey plan. However, *since the Halsey plan gives the worker only a portion of his saving, if time study is used as the basis, it is essential to set the standard time somewhat higher than the time which can be made, in order to provide sufficient incentive for the worker.* The task time set by job study thereby becomes a base for the management to work from rather than a task to be reached. However, under the Halsey plan the standard time is usually the average of previously recorded times. It is usual to guarantee that, when the time is once set for a job, it will not be reduced, despite the fact that conditions may not have been standardized or the jobs studied. The system is *liberal with the time allowance rather than with the premium percentage.*

Day rates are *guaranteed* under this plan, and to men who finish their tasks in less than the allotted time there is paid, in addition to the base day rate, a proportion ranging from one quarter to one half of the wages of the time saved. Thus the wage under the Halsey system is equal to the time taken times the hourly rate, plus the time saved times some fraction of the hourly rate:

$$E = TR + (S - T)\frac{R}{2}$$

This formula is for an allowance of 50 per cent of the hourly rate. The fraction of the hourly rate that is most generally used is about 33⅓ per cent, if conditions have not been standardized or the job studied. If the job has been studied, the fraction of the hourly rate that is used

will ordinarily range around 50 per cent. The percentage of the time saved—from 30 to 50 per cent—probably represents a rather large part of the total wage, and to make the percentage larger would be likely to create a distinct temptation to the employer to reduce the standard time when shown that it was considerably longer than actually necessary.

Another method of expressing the formula for computing earnings is as follows:

$$E = TR + p(S - T)R$$

To illustrate the working of this plan, consider a workman who is on an hourly rate of 70 cents per hour and has an 8-hour task given him, which he completes in 6 hours, working with a bonus of 50 per cent of the time saved. He will receive:

$$6 \times \$0.70 + \frac{8 - 6}{2} \times \$0.70 = \$4.20 + \$0.70 = \$4.90$$

It will be noted that he receives \$4.90 for 6 hours' work, which is at the rate of $81\frac{2}{3}$ cents per hour, or at the rate of $\$6.53\frac{1}{3}$ per day, provided that his time on the next job, which he may start immediately, is as good as the time on the first one.

The Halsey plan is easy to introduce. It is not absolutely necessary that there be preliminary studies other than those which will determine previous times on the jobs, and the plan is therefore excellent in any shop *as a sort of transition plan* to be used while studies of the jobs in the shops are being made and to arouse the interest of the workmen in incentive wage systems. This plan, in a slightly modified form, received its greatest amount of advertising from its use in the shops of the Yale and Towne Manufacturing Company, where it served as a transition plan.

One of the chief merits that is urged for the Halsey plan is that it promotes the permanence of the rate because of the method of dividing the profit on time saved between the employer and employee. If an extremely large amount of time is allowed for one job, and as a result the workman makes a very great saving of time, only a portion of the saving is given to the workman; this prevents the employer from immediately desiring to reduce the rate.

Since premium earnings often constitute a very large percentage of the total wages, the plan is criticized from the management point of view in that standard times prove in practice to be so very high that a temptation to reduce them in one way or another is sure to present itself eventually. Furthermore, standard times are sure to be uneven in that some will be very high and some will be comparatively low, resulting in an

unjust payment plan with "fat" jobs and "lean" jobs. In such cases there will tend to come about a picking and choosing of jobs among the workmen, or criticism of the allotment of jobs among them, just as in any plan where the rates are variable in the earning capacities they set. Furthermore, the workmen can beat the game by spurting on certain jobs to earn a premium and "soldiering" on other jobs to rest under *the guarantee of day wages.* This entire difficulty can be overcome by using time study instead of past experience as a basis for rate setting. However, it should be borne in mind that originally the Halsey Premium Plan was not based on time study; neither has this method been used extensively in practice.

The Rowan premium plan. Mr. James Rowan of David Rowan and Sons of Glasgow, Scotland, originated the plan which bears his name. It has been more popular in Great Britain than in this country, although several large American concerns, notably the Packard Motor Car Company, have at times used it in parts of their factories. Although a premium plan, like the Halsey, it differs in the method of computing the premium and in the base used. Wages, instead of being raised by an arbitrary percentage applicable to all similar jobs, are increased by a percentage equal to the percentage of reduction which the worker has made on the standard time of the particular job. This premium is a percentage of time worked, rather than of time saved. The day rate is guaranteed.

$$E = TR + \frac{S - T}{S} RT$$

If a worker finishes 36 pieces in an 8-hour day while working on a job for which the standard is 32 pieces per 8-hour day, his earnings at a base rate of 70 cents per hour will be as follows:

$$8 \times \$0.70 + \frac{9 - 8}{9} \times 8 \times \$0.70 = \$5.60 + \frac{1}{9} \times \$5.60 = \$6.22$$

It is apparent that the premium under the Rowan plan can never quite equal the day rate, for the value of the fraction $(S - T)/S$ constantly approaches unity as the actual time T approaches zero. Under the Halsey plan daily earnings can be greater than twice the day rate, but this is impossible under the Rowan plan. Ordinarily the premium is larger under the Rowan plan than under the Halsey plan. If the Halsey premium is 33⅓ per cent, the Rowan premium will always be larger up to 66⅔ per cent of the time saved. If the Halsey premium is 50 per cent, the Rowan premium will be larger up to 50 per cent of the time saved.

Although it is somewhat easier to justify the percentages used under the Rowan plan than those under the Halsey plan, nevertheless adaptations of the Rowan plan are far less widely used, chiefly because the method of figuring wages is so difficult that the worker finds it hard to understand and even harder to know what he has earned at any given time. It involves the use of a large clerical force for payroll purposes. Cost predetermination under either the Halsey or the Rowan plan is very difficult. The Rowan plan, like the Halsey plan, is very satisfactory during a period of transition from day work to a strong, measured incentive plan.

CHAPTER 24

WAGE PLANS BASED ON CAREFULLY ESTABLISHED STANDARDS

General considerations. Budgeting, standard costs, and other managerial controls are facilitated if the approximate time required to perform tasks is predetermined. Wage systems based on accurately predetermined tasks stimulate the worker to perform his task in the standard time which serves as the basis for production controls.

Wage systems based on job study prohibit management from drifting, because the establishment of standard conditions is a preliminary step to the development of all such systems. When the task has been accurately set on the basis of fair time for the job, the worker should receive all the advantage which is gained by his reduction of working time below task time. Therefore, these systems push the management quite as much as the management pushes the worker. In considering the foregoing statement, it should be remembered that job study may be used as a basis for setting a given task and yet the task may deliberately be set below what is known to be easily attainable by the average man. This is done when it is desired to build a wage program in such a manner that the bonus becomes a relatively large part of the daily earnings of the average man. Such programs frequently share with management the time saved.

The higher rates which the workmen earn under all these systems should take into account the fact that the management, as well as the worker, has had a hand in the increased production which is being secured. The employer has given more thought and money into the installation of the new conditions under the operation of these wage systems than in the operation of the premium systems previously discussed. The employee, on the other hand, must give somewhat more concentration and relinquish some of the freedom of action which he enjoyed when he performed the operation in his own way.

Piece rates based on carefully established standards. Piece rates based on motion and time study form the simplest incentive wage system. Such rates readily can be guaranteed by the management, if provision is made for a change in rate when the operation is changed. Piece rates thus set become an incentive wage because the worker should realize that there

is no cause for him to peg his production at any point. In order that such rates actually may be an incentive wage it is essential that, after the worker turns out the increased production made possible by the job studies, his pay be appreciably higher than his previous wage or the prevailing community day rate. The piece-rate earnings are easy to compute by the following formula:

$$E = NR$$

A guaranteed day rate with piece rates based on motion and time study. One criticism of straight piece work is that a worker may suffer a severe loss in earnings from conditions over which he has no control. This criticism is eliminated when he is guaranteed a minimum base rate. This plan somewhat complicates the problem of the budget director and cost accountant, but its evident fairness to the worker and its tendency to reduce friction between management and the men counteract the disadvantage in cost determination. Sometimes the guaranteed minimum corresponds to what would normally be a day rate when the failure of the worker to make his piece rate is caused by a shortage of material, machine breakdown, and similar factors. Payment of the predetermined average earnings over a recent period is usually made when the worker is transferred to a new job for the convenience of management. The payment of a guaranteed minimum rate to the worker places the desired share of responsibility on the supervisors. Day rates are frequently used for piece-rate workers starting new jobs, such as making new models in a mass-production industry.

Day rates based on output. In general there are two broad classifications of day rates based on output: (1) a series of rates related to productivity, and (2) one high day rate when the worker reaches standard production and a lower day rate when he falls short of standard. The utilization of a series of day rates based on performance provides for a number of classes of operators for any given job. These classes have their limits, fixed by the production of the workers. As the productivity of an operator increases or decreases, he moves from one of these classes to another and consequently has his rate changed. If records covering the performance of a number of workmen have been accumulated, it will soon be found that the workers will divide themselves into fairly well-defined classes which can have different rates of pay assigned to them. It is unnecessary that the individual be working always on the same job or type of job to utilize this system. If a record of the individual productive efficiency of each worker is kept for whatever task he may be working on and then all the workers are divided into distinct wage

groups, based on their general efficiency rather than their efficiency on any one particular task, this system may be used on all jobs. Under a scheme of this sort, advances or decreases in the worker's rate may be made at intervals of one month, three months, or any other period that is deemed best by the firm.

A second type of day rate based on production provides for day rates for jobs rather than for workers. Each job has a day rate assigned to it, which is far larger than the worker can earn by the ordinary day or old-fashioned piece rates in force in the factory up to this time. At the same time that this high day rate is established, a standard is set for the job. If the worker makes the standard or excels it, he receives the high day rate. If he fails to make the standard, he drops back to the old day rate or piece rate of the job or is paid by a new piece rate figured out in such a way that the worker suffers a loss in his pay envelope because of his failure to make the standard. Usually, for the most effective operation of this type of wage-payment system, it is necessary that the worker's performance be figured over relatively long periods of time and that he be not deprived of the high day rate merely for failure to make the standard over a comparatively short time.

This system has the advantage of the easy computation of the payroll that is characteristic of the day-rate scheme, and at the same time it enforces high production. It is very useful in plants where the workers object to the piece rate.

In style industries, in which new rates must be set constantly, the use of day rates based on production is much simpler than any other form of incentive payment. Since a worker has had assigned to him a day rate based on past performance, on short jobs that have not been time studied and which it may be unprofitable to so study he may be given the day rate which he has had previously. He may also be kept on this same day rate while production standards are being worked out for new jobs on which standards ultimately may be set.

Measured day work. During the past fifteen years management literature has been featuring discussions of "measured day work." [1] This program is an outgrowth of an attempt to recognize other factors than production in a wage program and still retain many of the advantages of the incentive plans.

A program of measured day work establishes standards of performance by careful time study and sets a basic hourly wage for each job classifica-

[1] See William R. Howell, "Measured Day Work vs. Wage Incentives," *The Society for the Advancement of Management Journal,* Vol. III, No. 1, January, 1938, pp. 54–57; also R. H. Rositzke, "Measured Day Work," *Factory Management and Maintenance,* Vol. 95, No. 2, February, 1937, pp. 45–46.

tion. In addition to the base rate for each job classification, the employee receives added inducements based upon his dependability, versatility, quality of output, and productivity. Length of service and other factors may be included if desired. The base rate for the job classification remains constant as long as the method and the conditions of the work or the general wage level remain unchanged. The added inducement which is part of the individual's wage may change from time to time, depending upon the worker's actual performance over the past period evaluated. The length of this period may be one month at the beginning of such a wage program but is usually increased to three months after the system is thoroughly established. Careful records must be kept of the worker's attendance, quality of work, productivity, and similar factors to enable the foreman periodically to evaluate his relative worth to the company.

In establishing the base rates, each job is carefully evaluated in terms of such factors as:

1. Mentality required to perform the work.
2. Skill required of the worker.
3. Responsibility for material and equipment.
4. Physical application and energy required.
5. Mental concentration required.
6. Working conditions.

Absolute uniformity does not exist by any means in the factors included in the job evaluation. The Kimberly-Clark Corporation does not include working conditions unless two jobs are rated exactly the same, in which case working conditions are considered to see if one job should be rated above the other.[2]

Measured day work tends to level out the worker's earnings more than do most incentive plans, particularly during periods of introducing new models or closing out old ones. In some instances the worker is paid on a weekly basis. This system places an additional burden upon supervisors to keep production per worker up to task; however, this problem is not so great when workers are paced by a conveyor. It does, however, become significant where the assembly line is not used. *Clerical work for payroll purposes is much less than under many of the incentive plans, but the work necessary to collect the data needed for periodically evaluating the individual's addition to his base rate raises the clerical detail to approximately the same level as that of most incentive plans.* Workers will not complain when their ratings are being raised, but friction can easily develop when an individual's rating is lowered. To avoid prejudice

[2] See "Compensating Plans for Executives and Workers," American Management Association, *Personnel Series, No. 30,* pp. 8–16.

it is wise to have the aid of supervisors other than the foreman in rating the workers.

Measured day rates eliminate complaints from the workers about shortages in their pay, which are frequent under incentive programs. A criticism of measured day work is that the basis is shifted from "an engineer's job standardization to the personnel man's job analysis." [3]

Taylor's differential piece rates.[4] The *differential piece-rate* system was Frederick W. Taylor's contribution to wage theory and practice. In keeping with his other scientific approaches, his system requires carefully established time standards and standardization of work, work place, and materials. The system has two piece rates: a high rate, which is paid to workers who make the set task or do better, and a low rate, which is paid workers who fail to achieve the task. The high rate is set at a point considerably above the loose community standard, and the low rate is set at a point below the community standard. Thus the task time for a given job may be 2 hours, with the high rate \$3.00 and the low rate \$2.00. If the worker does the job in 2 hours, he receives \$3.00, which is equivalent to a rate of \$12.00 per 8-hour day. If the worker takes 2¼ hours, he receives \$2.00—a rate of \$8.00 per 8-hour day. Although this last figure is somewhat misleading, since it may be assumed that no worker allowed to work under this system would fall down on every job during the day, it will be seen that the system is severe on the worker who fails to make the task.

The formula for computing daily earnings under Taylor's system is as follows:

$$\text{Below task: } E = NR_1$$

R_1 stands for the lower piece rate, which is intended to be a penalty for not reaching a task.

$$\text{At or above task: } E = NR$$

R in this instance is the standard rate that the worker is supposed to earn. The assumption is that the management has gone to great trouble and expense to insure that all management factors are properly working, and the only causes for failure to do the task within the allotted time are under the control of the worker. If the worker is a first-class man, he will make his task. If he is not a first-class man and cannot be trained to be a first-class man, he is not wanted; in fact, if he continuously fails to make his task, he will be discharged.

[3] See Charles W. Lytle, *Wage Incentive Methods,* Ronald Press Company, New York, 1942, pp. 142–143.

[4] *Ibid.*, pp. 178–179.

The Taylor differential piece rate is seldom found in its original form in industry today. The culling action at the point of achieving the task was found to be so extremely severe that the measurement of the task and the control of conditions set for the workmen had to be guarded with extraordinary care in order to avoid complaints or feelings of injustice on the part of the workmen. The fact that the Taylor differential piece rate does not guarantee a basic day wage is, therefore, the primary reason why it has fallen into disuse. Mr. Taylor recognized this point himself, for he said:

> When, however, the work is of such variety that each day presents an entirely new task, the pressure of the differential rate is sometimes too severe. The chances of failure to quite reach the task are greater in this class of work than in routine work, and in many such cases it is better, owing to the increased difficulties, that the workman should feel sure at least of his regular day's rate.[5]

Gantt's task-and-bonus system. H. L. Gantt, while associated with Taylor at the Bethlehem Steel Company, devised his task-and-bonus system, which Taylor in his later life strongly advocated. If the task is accomplished, the company receives a definitely known minimum output at a lower total cost per piece than under the older wage-payment systems. In return for his effort to make the task which the company has set, not only does the workman receive a reward which is large enough to make him wish to accomplish this amount of work, but also he *is guaranteed his hourly rate if he fails to reach the goal.* If he accomplishes the task, he is paid at his regular hourly rate for the time allowed for the task, plus a percentage of that time. This is equivalent to a high piece rate. Thus the workman has all the advantages of day work on a task he does not meet and all the advantages of high piece rates if he is proficient. The basing of the high rate on a day wage, although it takes the form of a piece rate, makes it possible to assign different rates for varying lengths of service or all-round abilities. The task-and-bonus system is built on the idea of the worker's earning the bonus every time. This point is of some importance when considering the relative merits of this system and differential piece rates. Both Taylor and Gantt paid a bonus to the foremen. Gantt gave an additional bonus to the foreman when all his men attained their tasks. This system is not suitable for use in a transition period.

The bonus, under the task-and-bonus system, is determined by the individual concern in accordance with its particular needs; it ordinarily ranges from 20 to 50 per cent of the task rate. Gantt actually varied the

[5] Frederick W. Taylor, *Shop Management,* Harper and Brothers, New York, 1919, pp. 78–79.

bonus percentage all the way from 20 per cent to 100 per cent, depending entirely upon the nature of the work. On the assumption that the bonus is 33⅓ per cent, which is fairly typical for ordinary machine-shop work, the formulas for computing the daily earnings under the Gantt plan are as follows:

$$\text{Earnings up to but not including task: } E = TR$$

$$\text{Earnings at or above task: } E = SR + \frac{SR}{3} = \frac{4}{3}SR$$

To generalize this formula to include any percentage that may be used as a bonus, let p represent this percentage. The formula will then read:

$$E = SR + pSR$$

To illustrate the workings of the Gantt system, let us assume that *A, B,* and *C* respectively produce 28, 32, and 36 pieces in a day of 8 hours, that the bonus is 33⅓ per cent, that the task calls for 32 pieces per 8-hour day, and that the rate is 70 cents per hour. The respective earnings will be as follows:

1. *A* will earn $8 \times 70¢ = \$5.60$, since he gets the guaranteed day rate.
2. *B* will earn $8 \times 70¢ + \frac{1}{3}\ (8 \times 70¢) = \$7.47$ or $1\frac{1}{3}\ (8 \times 70¢) = \$7.47$.
3. *C* will earn $9 \times 70¢ + \frac{1}{3}\ (9 \times 70¢) = \$8.40$ or $1\frac{1}{3}\ (9 \times 70¢) = \$8.40$.

The system is in substance a day wage for substandard workers and a task rate for men who are standard or better. In reality this task rate is equivalent to a high piece rate expressed in terms of standard hours rather than in terms of individual pieces. It is possible to compare the efficiencies of different departments by comparing the standard hours worked in each to the actual hours worked. The Gantt system avoids the criticisms that are made of the sharing principle common to the Halsey and similar plans. Also, it is easy for the worker to compute his wage. The Gantt plan, when installed under the guidance of Mr. Gantt, made wide use of charts to show the worker daily just where he stood in relation to attaining a task. Such a chart showed not only the status of the individual worker but also the corresponding status of his fellow-workers, thus creating friendly rivalry.[6]

Task systems as an aid in production control and cost predetermination. Any well-formulated task, with a bonus for making it, tends to cause the

[6] See Charles W. Lytle, *op. cit.*, pp. 185–189, for a detailed discussion of the Gantt plan.

workers to meet their goal every day. This is a great aid to production control and cost predetermination. It is in this respect that task systems differ most sharply from straight piece rates based on job study. In fact, there would otherwise be no real difference between task and bonus and the straight piece rate with guaranteed day rate. Under the latter system the guaranteed day rate is usually somewhat lower than the amount which can be earned on piece rate if the time set by job study is reached. There are thus several intermediate stages between the number of pieces equivalent to the day rate and the number equivalent to the standard. Under the task-and-bonus system there is no such condition. The day rate prevails until the task is achieved, when there is a sharp jump in the wage because of payment of the bonus. This sharp jump at the task point has the effect of causing the worker to meet the task set practically every time. Thus it is possible to predetermine overhead costs and use these overhead costs in developing standard costs. Furthermore the steady pull exerted upon the worker to reach the standard makes it possible to schedule and dispatch operations in the shop with the assurance that machines will be available at stated times. Although 5 or 10 minutes on one operation makes no difference in this matter, accumulations of such times over many jobs may readily disorganize a whole shop schedule.

The Curtis Publishing Company of Philadelphia made a very successful adaptation of the task-and-bonus system to its factory operations and to allied work. This application has since been extended to clerical operations. An example is the plan used by the trucking division. The various runs which their trucks made to warehouses, freight stations, and post offices were carefully studied and timed. Each run was evaluated at a certain number of points, on the basis of ten points for a fair hour's work. As a driver finished a run, his work ticket was punched, thus giving him current information as to whether he was ahead of or behind his task. For production in excess of ten points per hour he received additional compensation. The urge to reach the task and even exceed it was evident. Accomplishment was possible because, as job studies indicated, the basis of ten points was in reality lower than a satisfactory worker could produce with proper application to his task. Routes through uncrowded streets were carefully mapped for him, and it was only under most unusual conditions of traffic or bad weather that he was prevented from making ten points or more through causes outside his control, and in such instances the management awarded additional credit points appropriate to the occasion. The governed speed of all trucks prevented violation of speed laws, and the saving to the company remaining after payment of incentive compensation was derived from the initiative and appli-

cation of the drivers and loaders beyond that required by their standard task.

Emerson efficiency-bonus plan. Harrington Emerson's efficiency-bonus plan *guarantees the base day rate and pays a graduated bonus beginning at 67 per cent efficiency, culminating with a 20 per cent bonus at 100 per cent of standard.* In addition to the 20 per cent bonus based on the day rate times the time actually worked, Emerson paid for the full production in terms of standard time for all production above standard. Under this plan the efficiency of the worker is not determined on a particular job nor a particular day's work but over a pay period or even longer. There is thus less drive on the worker to make task time on each particular job, because, if he falls a little behind on one job, he can make up on the next. There is, furthermore, a gradual pull on the worker, and a man who is 98 per cent efficient makes more nearly the wage of the 100 per cent man than under the Gantt task-and-bonus system. Workers who are over 100 per cent efficient under the Emerson plan do not receive quite the wage of workers under the task-and-bonus system, for they receive their basic wage for the allowed time, but their bonus (which is usually 20 per cent) is figured on the time actually worked rather than the allowed time.

The efficiencies are expressed in terms of a percentage. Thus, if in one period a worker has actually worked 96 hours and has done only work for which the standard time is 84 hours, his efficiency is 87½ per cent. If he has done work for which the standard time is 91.2 hours, his efficiency is 95 per cent. If he has done work for which the standard time is 105.6 hours, his efficiency is 110 per cent. A sample bonus table under the Emerson system is as follows:

Emerson Bonus Percentages

Percentage of Efficiency	Percentage of Bonus	Percentage of Efficiency	Percentage of Bonus
67.00 to 71.09	0.25	89.40 to 90.49	10
71.10 to 73.09	0.5	90.50 to 91.49	11
73.10 to 75.69	1	91.50 to 92.49	12
75.70 to 78.29	2	92.50 to 93.49	13
78.30 to 80.39	3	93.50 to 94.49	14
80.40 to 82.29	4	94.50 to 95.49	15
82.30 to 83.89	5	95.50 to 96.49	16
83.90 to 85.39	6	96.50 to 97.49	17
85.40 to 86.79	7	97.50 to 98.49	18
86.80 to 88.09	8	98.50 to 99.49	19
88.10 to 89.39	9	99.50 to 100.00	20

The formula for computing earnings according to the Emerson plan is as follows:

Earnings from 66⅔ per cent of task up to task: $E = TR + p(TR)$. (The value of p is to be found in the table on p. 342.)

Earnings at and above task: $E = TR + (S - T)R + 0.20\ TR$, or $E = SR + 0.20\ TR$.

On the basis of Emerson's bonuses the wages earned by the man whose base rate is $1.00 per hour, working a 40-hour week under the percentages of efficiency indicated, will be for a pay period of 2 weeks:

Percentage of Efficiency	Base Rate	Bonus	Total Wage, Two Weeks
87½	$80.00	$6.40	$86.40
95	80.00	12.00	92.00
110	88.00	16.00	104.00

The Emerson and similar systems of graded bonuses exert less pressure on the worker to make task time with all its attendant management advantages. Since efficiencies are determined over a pay period, a man cannot work at maximum pressure on one job, thereby making a very high rate, and then take things easy on the next job, with assurance of a good day's wage. However, under the task-and-bonus system disciplinary action may eliminate any such program on the part of a worker.

Under the Emerson plan, earnings of the workers are posted daily, thereby mitigating somewhat the criticism that the plan is difficult for the worker to understand. The system creates much clerical detail and from this standpoint is expensive. In spite of its difficulties some progressive industries are using the system at present.

The Bedaux system. This system was perhaps the first of a number of point systems which provide a common denominator, man minutes, to which human activity in all industries may be reduced. Percentages of fatigue, predetermined by the class of job, are added to selected operation time to give task time. Task time is then expressed in terms of *standard work minutes* or *standard work units.*[7] If a particular operation calls for 30 *standard work minutes* or *standard units,* the worker is allowed 30 minutes for its completion. The wage earned is equal to the money value of the total number of standard work units produced. Day work and lost time that are not the fault of the worker are paid for at the rate of 60 standard work units per hour. The operator receives the base rate for each operation plus a fraction of the base rate expressed as "premium standard work units," or payment for the additional standard work units which he has done. If standard base rates are not reached, the operator

[7] Standard work minutes were formerly called B's, 60 B's making an hour or a B hour.

nevertheless receives such a rate for his performance. This amounts to a guaranteed day rate.

The chief contribution of such systems is that all work is broken down to common denominators, and hence comparison between departments or plants is simplified. The Bedaux plan makes careful use of job standardization and time study. The Bedaux engineers do not claim to have a standardized program for all situations but lay great emphasis upon adjusting their program to suit individual needs.

The formulas for computing the earnings of the worker under the Bedaux plan are as follows:

$$\text{Earnings at or below task} = TR$$

$$\text{Earnings above task} = TR + p(S - T)R$$

p represents the percentage agreed upon as the share of the time saved to go to the worker. S is found by dividing the number of standard work units by 60.

For quite some years now, in most cases where the point plan has been newly installed, the full time saved has gone to the worker.[8] This means that a worker having a \$1.20 base rate would receive 2 cents per minute for every standard minute of work produced over and above the standard productivity of 100 per cent (60 points per hour). When this is the case, $E = SR$.

The ability to compare the efficiencies of departments regardless of the nature of the work is a strong feature of this program. To illustrate, if the total point hours of production in a given department are 9000 and the actual number of hours worked is 8000, then the efficiency for the particular department will be 9000/8000 = 1.125, or 112.5 per cent. This figure can easily be used as an index of efficiency of the department.

Beginning operators may be paid a rate below the standard base rate and need not be advanced to the standard rate until, by maintaining a production of 60 standard work units per hour for several successive days, they have indicated that they are capable of earning the base rate that has been set.

One-hundred per cent time-premium plan. The one-hundred per cent time-premium plan is equivalent to the straight piece-work wage program having a guaranteed day rate with time instead of number of pieces as the unit of payment. It is also a modification of day rate based on production, as described on p. 335. The result is identical with the Bedaux plan when the worker is given the full time saved, on the assumption, of

[8] Letter to the author from F. A. Mattka, Director of Research and Development Bureau, Albert Raymond and Associates, Chicago, July 27, 1945.

TABLE 24.1

Comparison of Various Wage-Payment Systems

	Wage Systems Not Based on Carefully Established Standards				Wage Systems Based on Carefully Established Standards						
	Day Rate	Piece Rates without Job Study	Halsey	Rowan	Day Rates Based on Production	Piece Rate	Differential Piece Rate	Task and Bonus	Emerson	Bedaux	Wennerlund
Guaranteed day rate	Yes	May or may not	Yes	Yes	Yes	May or may not	No	Yes	Yes	Yes	Yes
Incentive for worker to reach maximum productivity	No	Not usually	Somewhat	Somewhat	Possibly	Yes	Very high	Very high	Yes	Yes	Yes
Maximum spur to best possible management	No	No	No	No	No	No	Yes	Yes	No	Yes	No
Spur to worker to reach carefully set task	No	No	No	No	Possibly	Somewhat	Yes	Yes	Somewhat	Somewhat	Somewhat
Payroll computation	Easy	Fairly easy	Fairly easy	Very difficult	Easy	Fairly easy	Fairly easy	Fairly easy	Very difficult	Fairly easy	Very difficult
Labor-cost predetermination	Impossible	Easy	Difficult	Very difficult	Fairly easy	Easy	Easy	Easy	Difficult	Easy	Difficult
Overhead-cost predetermination per unit	Impossible	Difficult	Difficult	Difficult	Difficult	Difficult	Fairly easy	Fairly easy	Difficult	Difficult	Difficult
Quality maintenance	Entirely dependent on character of product, methods of supervision and inspection, and other means taken to promote quality.										

course, that the standard task is the same for both systems. A task time is set for each operation. Each class of work may have a specific rate per hour, or the worker may be given a definite rate per hour regardless of the work he performs. The worker's time and efficiency relative to the standard task must be accumulated for each job in order to compute his earnings for the day. This is true regardless of whether the rate is assigned to the worker or the job. The worker is usually guaranteed the base rate for each job. To illustrate, let us assume that a worker works 4 hours on job A, for which the rate is 70 cents per hour, and produces 5 standard hours of work, then finishes the 8-hour day on a job for which the rate is 72 cents per hour, producing 4 standard hours. His earnings will be: $(5 \times 70¢) + (4 \times 72¢) = \$6.38$. If the rate applies to the worker instead of the job, his earnings in the situation just described will be as follows, assuming that his hourly rate is 70 cents per hour: *SR*, or $9 \times 70¢ = \$6.30$. The plan is simpler where the rate applies to the worker instead of a job. This plan has an advantage over straight piece work in the event of raising or lowering the base rates. The standard times remain the same, and the only change required is the hourly rate. This simplifies the record-keeping problem in case of changes and possibly has certain psychological advantages.

It is possible under the plan to give recognition to a worker's length of service by raising his hourly rate. When this is done, the one-hundred per cent time-premium plan embraces many of the characteristics of the measured day work plan.

Table 24.1 is a convenient reference for comparison of the various wage-payment systems and for information concerning their effect on various phases of operations.

CHAPTER 25

SPECIAL FORMS OF WAGE PAYMENT

Group payments. Group payments are of greatest value when the workers are operating on assembly lines or on a series of operations where each worker's output is dependent upon the productivity of the other members of the group. Group payments have also been used for entire departments and workers not associated with each other. Most of the various incentive plans can be used in paying groups. Since but one premium or bonus need be figured for each group involved, the amount of clerical labor is somewhat reduced. Group payments may also be used to reward foremen and other supervisors by including them in the group or departmental unit that is subject to the bonus. Group payments aid management in checking the efficiency of groups, departments, and the plant as a whole from day to day. No complicated statistics are necessary, but merely a review of a few time tickets.

Advantages of group-bonus plans. Group payments are presumed to promote worker cooperation. Indirect workers, even janitors and other laborers, when included in a producing group may develop a sense of responsibility for production and cooperate effectively to this end.

The group gives special attention to "bottlenecks" in production. Wherever in lone production there is a constant "hold-up" operation the group-bonus plan tends to speed this point up to the capacity of the rest of the line. The slow operations are assigned to the fastest men in the group, and thus all the help necessary is given to obtain the maximum production. There are "tricks of the trade" in every operation, and when several workmen are involved the best and fastest methods are worked out in very short time by the group members. A group bonus, because it makes one worker desire to help another, results in developing all-round men. This is of importance when production must be decreased, for, by reducing the number of men in the group, production is cut automatically.

Group bonuses have at times been used under conditions for which they are unsuited. If the jobs are entirely unrelated, it may be that the spurring action of one employee on another will not be so effective as anticipated, and under such conditions poor operators will profit from the better-than-average work of the best men. Under some conditions

the best workers will feel that an unfair advantage has been taken of them by figuring their wages partly on the efforts of inferior workmen. Group bonuses will usually work to advantage when a given operation is performed by several persons whose individual efforts are inseparable for wage-payment purposes, but they will not always succeed when applied to whole departments. It is probable that the relative ease of setting bonuses by groups does not compensate for the inaccuracies which occur. Under such conditions bonuses may preferably be paid on an individual basis.

Disadvantages of group-bonus plans. The fact that some workers receive wages which are based partly on the output of others may engender ill feeling and backbiting. Rate cutting is just as easy with the group bonus as with any other type of wage payment. If the management feels that the men are making too much money, a nonproductive worker, such as a sweeper, can be added to the group, with the explanation that the management had not included him through oversight but that he really was a part of the group at all times. Most of these disadvantages are not inherent in the system of group-bonus payments as such but arise largely from the failure of management to perform its function properly. It is true that the payment of a group may offer management an excuse for its action; such a performance, however, seldom deceives anyone other than management itself.

The size of the group. In actual practice groups have varied in number all the way from 4 or 5 to as many as 1000, or in a few cases even more. *When the group is small enough so that each man can see the results of his individual efforts, the system functions more effectively.* It is difficult to set a desirable mathematical limit on the exact size of a group. Probably a group ranging in number between 10 and 20 workers can possess all the desirable qualities sought. The worker can see the results of his efforts more clearly in a group of 10 than in one of 20. The elimination of one worker from a group of 21 imposes an increase of 5 per cent on each of the remaining workers if they are to absorb the additional burden. The elimination of one worker from a group of 11 results in an increase of 10 per cent to the remaining men under the same conditions. When the worker sees his bonus increase 10 per cent, this means a great deal to him.

Practically all groups of moderate size have a recognized leader and pace setter among the workers. This man may be the subforeman or, more frequently, one of the workers. When the group is small enough for this leader to make his influence felt, best results are derived from the group bonus. Through its unofficial leader the group will exert pressure upon lazy members who are holding down the group earnings. The in-

fluence of the worker leader diminishes very rapidly when the group exceeds 20 men. It is even more effective with a group smaller than 20.

Rate for beginners. The rate to be paid the beginner is not easily established from the standpoint of managerial cost predetermination and justice to the group and the learner. The value of the beginner in terms of actual productivity is frequently very low for the first few days. It naturally becomes relatively higher as experience is acquired. Even though the beginner may be given a relatively low day rate at first, he will often take from the group more than he contributes. This situation, which is not conducive to his acceptance by the group, may be handled in different ways. In some cases the learner does not share in the bonus for a short period, after which he is placed in the regular group. In other cases he does not share the bonus until he has reached or nearly reached standard performance. In other situations he is placed in the group from the beginning. When the group is large, the addition of the learner does not pull down the earnings of the other members so much, but it becomes a real problem in smaller groups. The solution usually consists of a compromise.

Supervisory bonuses. Group bonuses frequently are most effective when the foremen participate in the increased earnings. Therefore, usually the production bonus that a foreman receives is directly proportional to the productivity of his department. This is an essential feature of any foreman's-bonus scheme. In the Bedaux system it is easy to determine the number of "standard units" produced by a department and to give the foreman a bonus based on a previously determined scale. Under the task-and-bonus scheme a foreman may receive a bonus based on the number of workers under him who are themselves receiving bonuses. The foreman becomes directly concerned with the removal of all obstacles toward increased production, instead of leaving this problem to the higher executives or the methods men. Foremen's bonuses can be worked out for any phase of the operation of their departments, for instance, quality, accident reduction, or methods improvements.

Foreman's bonus based on over-all performance. Bonus plans for foremen have been used in many forms to accomplish specific purposes. The foreman's task is not a simple one but is made up of many factors, none of which can be neglected if his function is to be discharged. Several wide-awake enterprises have made the over-all bonus for foremen an integral part of their incentive program for these key men. Others have devised such a program for all executives from the grade of foremen up. Simplicity should be considered in all bonus plans, which, to be effective, must be so worked out that the individual can see the results of his efforts, not merely the pay check at the end of the period.

No standard practice is used in computing foremen's bonuses. Some of them are exceedingly complicated, and others are simple in computation. Supervisory bonuses that are within the possibility of attainment range all the way from 10 per cent to 25 per cent of the foreman's salary. Bonuses are more effective when they are paid on a basis of a relatively short period, such as a month. They are frequently paid on the basis of the ratio of actual departmental expense to standard departmental expense. For instance, one company pays a bonus for performance above 90 per cent of standard, paying 1 per cent of salary for each percentage above 90 per cent of standard but not to exceed 25 per cent of the base salary. In order to prevent manipulation of expenses, at times a three months' average of premiums earned is paid instead of the premium for the latest month. The bonus is usually computed in relation to controllable expenses, such as direct labor, supplies, perishable tools, scrap, and certain miscellaneous items.[1]

The Wilcox-Rich Division of the Eaton Manufacturing Company, Detroit, uses a supervisory bonus, which begins at 90 per cent efficiency in relation to attaining the budget, with a limit of 20 per cent of the supervisor's salary. For instance, on the basis of a moving average for 3 months, a supervisor is paid a bonus of 5.6 per cent if his efficiency is 95.6 per cent. If his efficiency is 112 per cent, his bonus will be 20 per cent. The supervisors' budget includes direct labor, indirect labor, supplies, maintenance, scrap material, and tools. A daily report to the foremen from the cost department serves as a strong stimulant to each foreman to watch his costs before they get out of hand. The objective of the company in using the foreman's bonus is said to be:

1. To reduce manufacturing expense.
2. To "Budget" such expenses on a "daily" flexible basis and to compare actual results with this budget.
3. To encourage all levels of supervision to be expense-minded.
4. To reward foremen for reduction in manufacturing expense by allowing them to share in the savings made.

Bonus for quality. Some persons feel that the various incentive systems militate against the maintenance of quality. They fear that the worker's interest in earning his bonus will cause him to slight quality. There are two general remedies which can be applied to this situation to help maintain quality while the worker is trying to earn his premium or bonus wage. The first of these remedies is to insure stringency of inspection and pay only for quality output; the second is to utilize some sort of quality wage bonus.

[1] See Charles W. Lytle, "Incentive Compensation for Foremen," American Management Association, *Production Series, No. 166,* New York, 1946, pp. 17–31.

If strict inspection standards are maintained and the workers know that defects will be returned to them for reworking or that they will be otherwise penalized, quality can be maintained. An adequate inspection system will ordinarily prove to be sufficient inducement to secure quality. Bonuses for quality are more frequently found only where quality, not quantity, is of paramount importance, although they are also used at times where quantity is desired.

Quality bonuses may be used with any wage system that has been discussed. In some cases they form the only type of incentive wage given. Quality bonuses divide themselves into two classes: (1) those which are utilized where quantity bonuses are impossible, or at least impracticable, and (2) those which are used in conjunction with some form of quantity bonus to make a composite wage system in which the pressure on the worker will be toward both quantity and quality.

It is easy to combine the payment of quality bonuses with bonuses for quantity. Combining such bonuses will prove an immediate check on rapid increase of production without regard to quality. Thus, in the weaving of cloth, a bonus may be paid on the production which is secured from the loom, and another bonus may be paid if the defects which are discovered in a certain number of yards of cloth are kept below a certain number. The relative amount of bonus to be paid for quantity and quality will vary with the importance of quality in the particular instance, for example, with the value per yard of the finished fabric.

A combination inspection system and quality bonus which is known as the "debit and credit bonus" has been devised. This may be applied on processes which involve a number of very short operations, as in some of the needle trades, where the cost of inspection after each operation would be prohibitive. Under this system each operator forms a check on all preceding operators for the quality of their work. If she discovers a defect in quality, she reports it to the foreman and receives a stipulated bonus for so doing, which is charged against the worker making the error. This is a rather unpleasant plan and is sometimes resented by workers who do not like to report each other. This automatic inspection scheme, although very harsh in its application, occasionally has proved very effective in raising quality on short operations.

Attendance bonuses. Attendance bonuses may be paid for attendance only, may include extra payment for promptness, or may be paid for promptness only. Bonuses of this type are frequently paid in money but are sometimes given in the form of a vacation or added days on vacation. If the bonus is paid in money, the amount is not usually very large. If it is paid in vacations, a frequently used basis is one day's vacation (or extra vacation, if the factory is already on a vacation basis) for each month of perfect attendance.

In times of acute labor shortage attendance bonuses are of value in increasing output, since they promote continuity of attendance by the working force and thus insure that any production program that is mapped out will not be hindered by lack of personnel to carry it through. The promptness bonus is particularly advantageous in this respect, inasmuch as it usually results in almost uniformly prompt attendance throughout the factory. As a result the production department can know, soon after the factory doors open, what vacancies in the factory force must be filled in a given department on that day in order that production may be kept flowing smoothly.

Many executives object to an attendance bonus on the grounds that, when a person is hired, he is expected to be at the factory on all working days and to be there promptly. Therefore an attendance bonus should be unnecessary and is an undesirable payment. In times of slack production attendance bonuses are likely to be quickly eliminated.

Length-of-service bonuses. There is some question just how far a differential in the base earnings due to length of service should be carried. Ordinarily a worker with 5 years' seniority doing as much or at times even more work than the 10-year man has difficulty recognizing the justice of paying the 10-year man more merely because of his length of service.

Some plants give workers of long service higher base rates than newer workers on similar jobs. A soap manufacturer has combined variable hourly rates, based on length of service, with piece rates. A certain number of units, or pieces, is set as an hour's task. Different workers are paid different rates per hour, based on length of service and ability to do more than one job, but their wage is determined by the units set for a given job. An interesting advantage of this method is that the task, being set on units per hour, is expressed in the same terms for every worker, regardless of his individual base rate.

Some plants have paid for long service by bonus or profit sharing, rather than by either of the methods just described. This bonus, usually a percentage of earnings, is paid regardless of the type of work which is performed or the money earned in a given period, and it increases as the length of service increases. Some plants have begun the payment of service bonuses as soon as 6 months after the individual has entered the employ of the concern, whereas many have deferred the payment for as long as 5 years. The basis of this payment depends on the type of worker that the company desires to reach and also on the length of service that is necessary to make the employee really of extra value from a producing standpoint.

Odd-shift bonuses. During World War II there was a marked increase in the payment of odd-shift bonuses. At the beginning of the war this practice was by no means general, yet as the war progressed it became increasingly the custom for the War Labor Board to approve these differentials and at times to order them.

Some of the plans for the payment of a bonus for night-shift work are as follows: (1) payment of a certain stipulated number of hours' pay per week in addition to the pay for the number of hours actually worked on the night shift, for example, payment for 3 or 5 extra hours; (2) payment of a bonus of a certain number of cents per hour worked on the night shift, as 5 cents per hour for the second shift and 7½ cents per hour for the third shift; (3) payment of a certain percentage of the day rate in addition to the day rate for odd-shift work, as 10 per cent and 15 per cent. The increase of the base rate for night work need in no way affect the operation of an incentive wage system, as the premium or bonus can be figured on the night base rate as easily as it can be figured on the day base rate.

Salesmen's remuneration. The same elements that cause inefficiency under the day rate in industry apply to salesmen under straight salary. Any commission or bonus plan is usually coupled with a basic salary or drawing account. Commission over straight salary is paid for sales above a minimum quota that has been set, and drawing accounts are paid back by the salesman through commissions earned, after which all commissions earned are his. Many firms give salesmen bonuses for unusually good performance. These bonuses may be paid in addition to the regular commission, or they may be used in connection with sales people who are primarily or entirely paid on a salary basis. Bonuses are likely to be paid quarterly, semiannually, or annually, whereas commissions are usually paid at shorter intervals, frequently to correspond to the regular pay period.

Basic salaries can be determined on the basis of the salesman's past worth to the company, plus his knowledge of the company's products, and with regard to the type of customer with whom he is dealing. Commissions vary with the extent to which sales price exceeds cost and with the total of goods sold. Frequently the same salesman will receive different commission rates for selling different products at the same time. A slow-moving product that seemingly is encountering considerable sales resistance may carry a larger commission than another article that is moved more readily. The same product may carry a different commission to salesmen travelling in different territories, the higher rate being paid to the man in the territory less densely populated or less productive. The commission for a sales person in department stores is sometimes ad-

justed according to the seasons in order to maintain a more equitable wage. Where this is the program, the commission for the slow period, such as August, is usually higher than for the month of December.

Advantages of the straight salary are somewhat greater in selling than in manufacturing industries. The advantages claimed for the straight salary for salesmen are:

1. Management may exert more direct control over the salesman's activities, such as sending him to any territory or part of his territory, assigning him to special tasks or to selling special items.
2. The plan is simple and easily understood.
3. Record keeping is simplified.
4. Security is given the salesman in that he knows what his earnings will be.

The main advantages of the commission plan are listed below:

1. A strong incentive for increased effort is provided.
2. Flexibility to meet changing conditions is more readily achieved.
3. Employees are paid largely in terms of results, which is the only truly equitable basis of payment. The efficient salesman is not penalized, and the substandard one is not overpaid.

In connection with the advantages of the commission form of payment it will be observed that this method corrects the weak points in the salary system. It is also true that the strong points of the salary basis of payment are the weaknesses in the commission plan.

The ideal plan for paying salesmen would meet the following requisites:

1. It would provide payment in terms of sales effort and accomplishment.
2. It would provide security in that the salesman knows that he has an income at all times sufficiently high to meet his *minimum requirements.*
3. It would provide a strong incentive for increased effort and accomplishments.
4. It would be easily understood and would not entail excessive clerical costs.
5. It would enable management to control the salesman's activities, to use him where he is most effective for the enterprise as a whole.
6. It would be flexible enough to enable management to meet changing conditions as they arise.

Salaries of executives. Although the detailed nature of an executive job has little relation to the proper salary to be paid for it, there is much to be gained in large companies through the development of a salary scale for executives based on some of the fundamental characteristics of the several jobs and of the character of the men needed to fill them.

In the main, there are two groups of executives: *top management,* as represented by the policy-determining officers, and *middle management,* comprising a very important group of operating executives below the rank of senior officers. The middle-management group includes the colonels and majors of industry, whereas the top-management group com-

prises the generals. The generals outline the policies and in an over-all way direct their execution, and the majors and colonels actually carry out these policies. It is very difficult to set exact limits on top executive salaries. They must be high enough to hold men of superior business generalship, or else they will enter business for themselves in direct competition with their former employers. It must ever be remembered that executives of demonstrated ability have little difficulty in securing financial backers. It is also true that the salaries paid top executives are influential in determining the salaries of middle management and all the other members of the supervisory group. Salaries of business executives bear a geometric ratio to those of their subordinates, not merely an arithmetic one. A chief executive who successfully directs an enterprise like General Motors is not overpaid if his base salary is $100,000 or more, with bonuses bringing the total to a half-million dollars. On the other hand, a man with mediocre capacity would be very expensive to a corporation if he paid a million dollars annually for the privilege of being the chief executive.

As a basic principle it is good practice to pay executives *a base salary* sufficiently large to cover their needs and the *rest of their salary* in the form of bonuses or profit sharing. Such a program provides a strong incentive, makes them have a proprietary interest in the business, and does not saddle the enterprise with high fixed salary charges during periods of slack business. Another form of partial executive remuneration is to provide adequate pensions for them on retirement. This plan has the special advantage of not requiring the executive to pay special attention to building up a personal estate for his retirement, thus enabling him to give undivided attention to his company duties. A second advantage is that money paid into a pension fund is not taxed while the executive's earnings are high. Income taxes are paid only when the pensions are received. Frequently $100 paid into an executive's pension fund will net him more than will $200 paid to him as regular salary.

Among the factors that may be taken into account in setting a scale for executives' salaries are the following: education necessary, amount of business experience required, amount of specialized business experience needed, amount of administrative experience necessary, number of workers supervised, character of workers supervised, and amount of payroll supervised. A table fitting the needs of a particular business can be worked out, with salary ranges within each step of the table. Then the salary of an executive whose duties and qualifications fall within any step of the table is set on the basis of the salary specified in the table. Changes in payroll affecting executives must usually be studied and approved by one of the major operating officials of the company, not by rate-setting or similar groups.

PART VII

BUYING, SELLING, AND TRANSPORTATION

CHAPTER 26

THE SALES DEPARTMENT

The economic function of selling. Goods are not completely produced until they have been turned over to the ultimate consumer for his use. In this sense the sales function is a very vital phase of production. In the terms of the economist, the selling function creates *possession utility.* At times the sales force may control not only *possession utility* but also *place utility.* It should be clearly recognized that economic terminology is not the language of business. The businessman divides business functions into three broad areas, namely, production, finance, and sales. The growth in the size and complexity of present-day markets has forced management to give increasing attention to the organization of the sales force and to the formulation of policies to guide this organization.

The importance of the sales function. For some years before World War II the selling function was the one that controlled the volume of business because the productive capacity of most industries was greater than the demand for their products. This situation is known as a "buyers' market." During the war conditions changed, and the "sellers' market" undoubtedly will continue for some years. Nevertheless, in view of the potential capacity of American industry, it is reasonable to expect an early return to the time when the sales department will set the pace.

Although it is reasonable to expect the sales department to play a leading part in business, it is unfortunate for any company to get into a position where the system of sales dominates the company. Any manufacturing enterprise which places itself in a position where its distributors may dictate what will be manufactured and when this product will be turned out is in a very precarious condition for long and prosperous operation. In the past, particularly in certain textile lines, selling agents have dominated manufacture to this extent, and a usual result has been that the manufacturing plant has sooner or later been taken over by the selling agents; after this time a policy of coordination rather than of dicta-

tion has been instituted. In the discussion of control of sales there is thus assumed a sales or a merchandising manager having actual control over the means and methods of distribution, as well as responsibility to the general management of the business. This sales manager, although full of enthusiasm and drive, and with the ability to go out and get business in the old-fashioned way, must also be cool and calculating and able to plan and direct the efforts of his subordinates, as well as to coordinate their efforts with those of the production and financial staffs.

The organization for sales. The over-all organization structure and philosophy influence the organization of the sales department. A large corporation manufacturing a series of products that are distinct in certain major characteristics may be organized on a divisional basis according to the products. In this event there may be no central sales office at all, or there may be a company sales manager who merely renders staff advice. The General Motors Corporation is organized on such a divisional basis. If a company is not organized on a product basis, the sales department may be organized on a regional basis (sometimes called divisions) for control purposes.

The actual organization of the sales force will be greatly influenced by the nature of the product, the desired market, the methods selected for demand creation, the distribution channels used, and various combinations of these factors. Two large department stores, however, may follow different organizational principles even though they sell the same product. In one store the buyer may be in direct charge of the sales people, merchandise, and displays of his department, and in another store have no direct control over the salesmen. The advertising department in a toothpaste-manufacturing enterprise may report directly to the president and even have the sales department as a division of advertising, whereas advertising in most organizations is a department under the sales division. Sales promotion usually is a function performed by a department of the sales division. In some organizations it may be a separate department coordinate with the selling organization, and both may report to a common head who is a major executive.

Centralization versus decentralization. The two large mail-order houses also have many retail outlets. Each is headed by separate managers and in many respects is run as a distinct organization. Again the question of home-office control arises in organizations having national distribution. If the branch managers have relatively little authority and have to receive approval from the central office for such items as credit and sales campaigns, they usually are lower paid, but the organization lacks flexibility and service suffers. If the branch managers oper-

ate within certain broad policies but otherwise as if they controlled independent concerns, the organization is more aggressive and flexible; this type of organization, however, requires a higher type of personnel and is more expensive. Usually the additional expense is justified unless the products are highly standardized. Frequently such items as advertising, accounting, and office procedures are controlled from the central office, and the manager is given much latitude in the actual selling and in purely local matters.

Specialization in the sales force often is desirable. Segregation of the salesmen may develop from the fundamental characteristics of the buyers of the same article, or it may result from the differences in the nature of the products, or both. Taxicab-fleet owners, automobile manufacturers, and passenger-car owners buy automobile tires, yet the problems arising in selling to each group are distinctly different and can best be handled by specialists. The Nash-Kelvinator Corporation and the General Motors Corporation manufacture both automobiles and electric refrigerators. The technical problems involved in selling these two products can best be cared for by specialists in each field. However, where customers are few and are separated by great distances, the advantages of specialized skills of different salesmen may have to be dispensed with in the interest of economy in travelling expense. Foreign trade usually presents so many special situations that they can best be cared for by a separate department or organization within an enterprise. In some instances a separate corporation may be organized to carry on the foreign trade for the parent corporation. The various situations arising in trade that may in one company call for segregation of salesmen are many. The controlling principle should be that the organizational structure is itself a means to an end. The same business enterprise may wisely use a different structural organization of its sales force in different areas at the same time, or at different times in the same area.

To be effective the organization must constantly be evaluated in terms of its reasonably current expectations and demands. It should continue as a living entity coordinating the active interests of all concerned and not be a "hang-over" from conditions that have long since ceased to exist. Theoretically desirable sales organizations may well be created by specialists in this field, and it is desirable for the sales manager to have such programs before him as a goal to strive for. As a matter of practical necessity, he must, however, use the available personnel and, temporarily at least, adjust the organization to the capacities of this personnel. A planned training program will reduce the number of special adjustments that have to be made to the desired organization.

The merchandising department. In some companies the over-all selling function is handled by a department of distribution with major subdivisions of sales, advertising, and merchandising. Terminology is not standardized, but the merchandising department usually serves as a coordinating and analytical department primarily concerned with product design, standardization, simplification, and prices. This department approaches product design from a commercial, not a technical, standpoint. It strives to study consumer needs and style trends. The merchandising division correlates suggestions for the product regardless of the source, studies means of improving the attractiveness and utility of the packaging, makes market surveys, issues catalogues and price lists, and acts as an intermediary between engineering, production, and sales.[1]

The nature of the product and the extent of the market. Probably no single factor exerts a more powerful influence upon the organization of the sales force than the nature of the product. The methods used in marketing California fruit differ materially from those used in marketing lumber or hardware. There are two major classifications of goods, namely, producer's and consumer's, and each has its own special problems in marketing. Between these two classifications there are many gradations. The same product may be a consumer's good in one instance and a producer's good in another. When sold to the housewife, cloth is a consumer's good, whereas it is a producer's good when sold to the dress manufacturer. The selling organization must be so constructed that not only the nature of the product, but also the buying habits and customs of the purchasers, will be given due consideration.

If the market for the product is national, the organization of the sales force will have to be adjusted to this situation. On the other hand, a product may by its nature be restricted to a local market and thus require a different type of selling organization. The difference in the organization may not arise out of the difference in the size of the sales force, although this may be a factor. For instance, ice cream is usually sold in a local market, whereas files and glue generally have national distribution. An ice-cream manufacturer in Chicago may have ten or fifteen salesmen and a national distributor of files may have the same number, each firm performing a satisfactory service in its respective field. The market may be confined not only to a single city but even to one sector of this city. The nature of the product may influence the decision, or the policy of distribution may be controlling. In some cases a manufacturer may decide to cultivate a given territory intensively, whereas in

[1] See Paul E. Holden, Lounsbury S. Fish, and Hubert L. Smith, *Top-Management Organization and Control,* Stanford University Press, Stanford University, 1941, pp 53–54, 178–184.

another situation the same manufacturer may conduct an extensive sales program. Within the same area a given manufacturer may cater to two or three different markets. In Detroit, for instance, a paint manufacturer may sell directly to the automobile producers and governmental units, and through retailers to contractors and to householders. Each of the three markets may require special salesmen, a fact which will definitely influence the organization of the sales force. The custom that has grown up in a given industry may also influence the organization of the sales force and the method of distribution.

Distribution channels. Both the nature of the product and the market that is desired definitely influence the organization of the sales department and the choice of distribution channel. Rarely indeed are automobiles sold in department stores, yet women's stockings always are. On the other hand, women's stockings have successfully been sold directly to the consumer. Certain products require specialized knowledge to demonstrate and sell. The ordinary retail outlet is seldom in a position to give this specialized service. Machine-tool manufacturers have often found the mill-supply houses unsatisfactory as outlets for their products and have sought to deal directly with the users of their equipment, although this is usually an expensive method of distribution. Staple products are successfully marketed through the regular retail outlets. A large manufacturer of several products may utilize many different outlets. In one area he may sell through wholesalers and jobbers and in another through his own branches and warehouses, whereas in still another region he may offer a product through chain stores. Here again such factors as the financial resources of the company, custom, the extent of the market, the nature of the product, and the special inclinations of the management may be controlling.

The choice of methods used in promoting sales is very closely connected with the channel of distribution. This phase of the selling program involves such items as the use of personal salesmen, selling through correspondence, the use of samples, the use of advertising, and the medium to be used for advertising. These methods may be used singly or in any combination. The actual methods used directly influence the organization of the sales department. Mail-order selling or selling by correspondence requires a distinctly different selling organization from that used in house-to-house canvassing. If large-scale advertising is used, a special advertising department or the employment of an outside advertising agency will be necessary. When an outside agency is hired, provision must be made within the employing organization to approve the advertising in a general way, at least to see that it conforms to the over-all objectives and policies of the enterprise.

Determining the sales price and credit policy. Many factors such as the following are considered by the sales department and the entire operating organization in determining the sales price for a given article: (1) whether the company has a monopoly or is in a competitive position; (2) whether to "charge what the traffic will bear" or to determine price on the basis of cost of production; (3) whether large volume with low unit profit or relatively small volume with high unit profit is desired; (4) whether the demand for the product is elastic and whether substitutes, actual or potential, threaten the market; and (5) what the short-run competitive price in the given market is. In the absence of a monopoly, competitive effort in the long run will usually tend to reduce high unit profit. In an effort to maintain a semimonopolistic position, a company may engage in intensive advertising. Although intensive national advertising by radio, magazines, newspapers, billboards, and other media may not give a technically monopolistic advantage, in substance it approaches this result, for only those organizations having tremendous capital available can successfully enter the field. This situation is well illustrated by the toothpaste manufacturers. Relatively few articles have an inelastic demand. Acceptable substitutes are available for most products when prices get out of line. In the short run a manufacturer may be forced to sell his product at a price somewhat less than that necessary to recover all costs, particularly during certain periods of the business cycle. Price determination is not solely a function of the sales department. In determining basic policies, the board of directors may elect to produce a high-quality product to be sold to a restricted market on the basis of a relatively high unit profit. The ultimate long-run price is usually a compromise between external influences and the many interests of the internal organization.

If the enterprise does a strictly cash business, the necessity for a credit department is eliminated; likewise much of the record keeping is reduced. In some organizations the credit department answers directly to the treasurer, whereas in other concerns it may be a functional unit of the sales department. Selling on credit, even on open accounts, involves additional burdens of investigation, billing, and follow-up of collections, as well as computations of discounts for cash or payment within a specified period, such as ten days. Such a sales program ties up additional funds and thus influences the amount of money required for a given volume of business. Either system—selling for cash or on credit—directly influences the organizational structure of the enterprise.

Closely related to sales price is the factor of service rendered and the basis of payment for it. One manufacturer may give free service for a period of three months to a year. Naturally payment for this service

must be included in the original selling price. Another manufacturer may operate his service department as a convenience to his customers and a part of his advertising program, charging the customer the actual cost, in some instances not including overhead and in others including all determinable costs. Still a third controlling philosophy is used by other manufacturers, namely, to charge for service not the actual cost but an amount sufficiently high to give a profit. Again, there may be various combinations of the foregoing policies, such as providing free service for the first three months and then setting charges that will make a profit on the operation of the service department as a whole.

The sales manager. The energies of the sales manager, in addition to his constant drive to sell what is being produced or what will be produced, are partly occupied with thoughts of new lines of products to be developed. The sales manager has to pass on the practicability of the product from the selling standpoint, on the desire of the market for a given product, and on the power of the market to absorb new products. In considering these conditions, the sales manager keeps constantly in mind the necessity of meeting changing consumer demand and of creating new demand which will be directed toward all or some of the products of his particular plant. The sales manager is aided in his search for new products or new uses for his present products by the technical research staff and the merchandising department. In addition to providing the consuming public with what it wants and when it wants it, the sales manager is faced with constant pressure from the producing organization to aid in reducing seasonal variations. These considerations are important whether the company manufactures primarily to schedule or primarily to customers' orders. If the latter plan of operation is followed, the principal difference is that the sales manager's task is much more difficult, in that he has to sell and plan for sales in terms of the extent to which current orders fill particular portions of manufacturing capacity. Delivery dates on new orders that are taken must then dovetail with promises that have been made on orders already turned over to the production departments for manufacture. If the plan provides for the manufacturing of standard products to schedule, the control of sales becomes somewhat simpler, although the energies of the sales force must frequently be directed toward the movement of certain articles which the market suddenly rejected after the budget and the manufacturing program were developed.

Sales promotion. The sales department occupies a dual relationship with respect to consumer demand: it seeks to discover what the public wants and to satisfy this demand. On the other hand, it is faced with the problem of acquainting the public with new products, and in this

function it creates new demands. In large companies such promotion work can, in its routine aspects, be handled in the main by a sales-promotion department, operating only under the general direction of whoever is in major charge of distribution. However, the sales manager will be forced to lay out the major lines of operation for the sales-promotion department, if he is to correlate their work closely with that of his own direct assistants and with the administrative program which has been laid down for the company as a whole. The sales-promotion department must be in constant touch with the salesmen or distributing agencies which are actually selling the product and must be in a position to aid them to push a certain article in the manner which may seem most effective at any particular time. The control of advertising campaigns and appropriations may be placed under such a department, although the actual preparation of advertisements and direct contacts with publications or printers are often left in the hands of an advertising department or with an advertising agency.

A sales-promotion department should know the customers and the trade thoroughly. In addition, it should be completely familiar with the products that are being manufactured. Through the head of sales, it knows the programs which have been laid down for a forthcoming period, and with all these factors in mind it constantly strives to promote the realization of the developed sales program. It gives the salesmen the home-office aid that is necessary when and where it is necessary, and in so doing it cooperates directly with the sales manager or whoever else is in direct charge of the salesmen. It maintains a stock of the various "dealers' helps" which have been devised and distributes them to dealers in a way that will promote any particular campaign or program that has been determined upon.

Planning sales effort. Sales planning, certain aspects of which have previously been discussed, must be extensively developed before a sales program can be drawn up. Some of the most effective planning, however, must be done after the formulation of the program and in an attempt to carry it out. In laying plans to carry out one sales program, lessons are learned which are of material assistance in formulating succeeding sales efforts. Planning for sales is predicated on the idea that the sales manager must act strictly on facts, must carefully determine these facts, and must supervise his force in a way that will bring measured results from these facts.

The details of the sales plan will be influenced by the decisions reached after due consideration of the factors discussed earlier in this chapter: (1) analysis of the nature of the product; (2) analysis of the market to

be reached: (3) distribution channels; (4) organization of the sales force; (5) price of article and credit terms.

Salesmen tend to follow the line of least resistance rather than the one of greatest long-run profit to the organization. Some sales managers have detailed route lists prepared for each salesman, indicating what towns he is to visit and perhaps whom he is to see in each town. Much valuable information can be secured from the salesman himself in this connection, but he should be called upon to present adequate reasons why certain towns or possible customers should be omitted from the list. Salesmen easily fall into the habit of neglecting outlets which they do not happen to like. Some means must therefore be provided of checking calls against route lists which have been provided for them. Some firms provide an exact schedule for their salesmen, detailing precisely what calls shall be made on specific days and demanding an adequate explanation of failure to make expected calls. One large house-to-house distributor of food products boasts that it can tell just where any one of its sixteen hundred salesmen is at any time and not be in error greater than a distance that can be travelled in a half hour. Although it is frequently advisable to schedule the salesman's program much more in detail than was formerly the practice, he should be allowed considerable freedom to adjust this schedule as occasion demands. Errors usually arise because of schedules being controlled by a clerk who is not familiar with operating conditions in the field. Although a clerk may do the paper work even better than a sales manager or one of his major assistants, when questions of judgment arise, decisions should not be left to a clerk.

Setting the sales quota. In order to make equitable the opportunities and compensation of the salesmen, territories must be clearly defined and studied. The quota itself, like any other task, should be fixed in such a manner as to be readily attainable; it should be based on careful study of the current situation, not on previous sales or any arbitrary increase over previous sales. Such a practice as an arbitrary increase merely penalizes the salesman who has consistently done well and throws out of balance the plans for total sales that are being laid. Although quotas must be fairly well worked out before the sales estimates are submitted for budget-making purposes, they will have to be revised after the adoption of the budget to insure that its schedules are attained.

Quotas must be set with the basic factors within the territory in mind. Inaccessible population cannot be counted. Some knowledge of trade customs within the territory is involved in this question. With goods which are sold for household purposes such factors as the strength of mail-order houses must be taken into account, and the nature of transportation facilities must be considered. With products which are used

largely in trades or in manufacture, the usual channels of purchase must be thoroughly studied. The only population of value is that which may properly be expected to be in the market for the product. Thus, if quotas are being set on shirts retailing at $5.50, the available population is reduced considerably under that which must be considered in setting quotas on shirts which sell for $3.50. Crude population statistics are, therefore, of little value in setting quotas, although they may be utilized as a point from which to start. The number of outlets must be determined. This may be the number of dealers or in some cases the number of direct users of a product. Thus the quota of a branch sales office of an automobile-accessory manufacturer located in Detroit will necessarily be higher than the quota of the Cleveland branch. The volume of prior sales must be given some consideration, as must the extent of competition within the particular territory. Paucity of potential buyers may run up the cost of sales to the point where it may be desirable to abandon certain territories, such as the sparsely populated areas of Nevada. The relative advertising expenditures in comparison with those of competitors must be taken into account. Market conditions within a territory should affect the quota set for it. Thus crop failures in a farming community must affect the quota set for the community the next year for nearly all products. New sales efforts may affect all quotas equally, or they may affect some to a greater extent than others. If intensive advertising campaigns are to be run in certain sections, the quotas for those sections must be advanced correspondingly, as the salesman and dealer aid from this source will be considerable.

Analyzing the sales results. A careful analysis of the sales results is necessary in the evaluation of any scientific sales program. Territories which have proved to be unprofitable must be given up. Territories which cannot be adequately covered by one man or which might be better handled by another branch should be adjusted to fit ascertained conditions. Careful study of campaigns which have been previously planned will give satisfactory information for changes that affect subsequent campaigns. A careful study of the monthly comparisons of actual sales against the sales budget frequently reveals errors in either the budget or the sales plan. The keeping of accurate sales records and careful planning in the light of organized experience distinguish the modern sales executive from the so-called "star salesman," who is frequently strong in performance but weak in coordinating and directing the efforts of others.

The sales manager is enabled, after he has established the control which has been outlined, to cooperate more intelligently with the production executives, to determine accurately his best salesmen and the best branches,

and to reward them accordingly. The sales manager is enabled to travel into difficult or highly competitive territory and to lend a helping hand to his salesmen. Special awards, bonuses, and contests for salesmen have real significance if sales have been previously planned. The sales manager will find that through these aids he will have the concerted effort of the whole sales force directed towards the fulfillment of the sales promises which have been made to the general management and the other operating departments.

Selecting, training, and maintaining the sales force. Sales managers are frequently hesitant to make complete use of the employment department, preferring to hire their own men. This attitude may be justified where the employment office is developed primarily to serve the factory personnel. In modern employment offices, however, there are well-trained men *who are specialists in hiring office and sales workers, just as there are others who devote their time to employing mechanics.* The qualifications desired in a salesman are determined largely by the particular sales task to be performed. Some products require technically trained men to sell them successfully. Certain types of experience have been found in other cases to provide a desirable background for selling special products. The man who has made a success of selling taps, dies, and abrasives has been found by hacksaw and file manufacturers to be a likely prospect as a salesman of their products. The factory and service departments frequently provide excellent men for the sales group. Such employees are already known to the management, are familiar with company policies, and require a shorter training period. The training program should be adjusted to the needs of the particular enterprise. The understudy system, after an intensive training period in the factory, is used extensively for travelling salesmen. In department stores the sponsor system is frequently used. Some organizations have regular sales courses through which they put all new salesmen. Another phase of the training program is the "in-service training." This program is particularly difficult when salesmen are operating far from the home office. Under such conditions there are two basic problems. One is to keep the salesman informed regarding the improvements in his product, and the other is to keep him enthusiastic concerning the policies of his company. Correspondence courses especially designed to acquaint the salesman with his products, special sales helps pointing out technical developments and new sales methods, and regional or home-office conferences are the common methods of training field salesmen. If the sales people are under one roof or within a given area, the sales conference is most successful, even though sales helps may be used.

A salesman must be selected for a particular territory with a view to the buyer resistance or acceptance within the territory. Polished salesmen may succeed in one place, whereas rough-and-ready salesmen will succeed in another. Although a really successful salesman appears to adapt himself to whatever conditions he meets, buyer resistance is reduced by properly apportioning territories among the sales force. The enthusiasm of salesmen in attaining sales goals can be stimulated by methods of payment, as indicated in Chapter 25. If both a salary and commission are paid, the two methods must be balanced so as to be most effective. Commissions should be based partially on the success of the salesman in reaching quotas which have been established for him. In other words, compensation must be based on production, and production in turn must be determined in relation to a set task and quota. This task or quota may vary with the product, with the territory, or with the salesman.

A properly constructed plan of compensation is an aid in holding the new salesman and serves as a strong incentive for the experienced man. The most successful salesmen are highly individualistic and readily develop a partnership attitude toward their companies, particularly when their reward is directly related to their effort.

CHAPTER 27

THE PURCHASING DEPARTMENT

Functions of the purchasing department. The purchasing department specializes in material procurement, thereby relieving the operating departments of the time-consuming task of locating a source of supply, securing quotations, placing orders, and following up deliveries. This specialization results in better long-range supplier relationships, more efficient planning for an even flow of material into the plant, more reliable records upon which to plan future purchases, and a closer coordination of procurement with the current phase of the business cycle. The direct economic contributions of the purchasing department are *place utility* and *possession utility;* however, these are closely related to *time utility,* since the materials must be on hand when needed. The major objectives of the purchasing department may be summarized as follows:

1. To provide necessary materials, supplies, and services of the quality and kind required
2. To provide these materials, supplies, and services for the enterprise so that they will be available when wanted.
3. To secure these items at the lowest possible cost consistent with sound business practice and ethical procedure.
4. To advise management regarding the possibilities of economies to be secured by manufacturing an item rather than purchasing it or, in other instances, by buying rather than manufacturing.

To carry out these major objectives, the purchasing department is required to perform more detailed functions, as follows:

1. To interview salesmen regardless of whether an immediate purchase is contemplated, thus maintaining one of the important public contacts.
2. To formulate specifications or at least to cooperate in their final determination.
3. To secure quotations on the major purchases, compare these quotations, and place the order in keeping with the policies of the organization.
4. To purchase directly all smaller items not requiring a quotation or bid.
5. To formulate interdepartmental policies and to participate in the formulation of company policies pertaining to purchasing and public relations that influence purchasing.
6. To inspect (or to see that inspection is carried out if it is performed by another department) all purchases for quality and count.
7. To follow up all purchases to see that delivery is made when promised.

8. To approve all invoices for payment.

9. To be on the alert for new developments either in processes or in materials, and to call them to the attention of the major executives charged with the specific responsibilities involved.

10. To maintain adequate records of sources of supply and the nature and reliability of each source.

11. To study economic trends in the market for specific commodities as well as business in general.

These functions are to be performed by any well-organized enterprise even though they may not all be centralized in the purchasing department. For example, the keeping of inventories at a minimum consistent with production requirements is a function of the purchasing department in many institutions, although this responsibility frequently is placed upon the stores department, the production-control department, or some other department.

The location of the purchasing department in the organization. The importance of the purchasing department in factories manufacturing complicated products may depend on the degree of standardization. If the product is standard, the scope of the purchasing agent's authority usually has been so limited by those who drew up the specifications that his task is fairly simple and, therefore, one that is subject to general manufacturing control. If the product is not standard, the purchasing agent usually must decide many matters concerning the purchase of material which would not come within his jurisdiction with a standard product. Hence his position within the organization will be correspondingly increased in authority and importance. Tables 27.1 and 27.2 show the location of the purchasing department in a substantial number of plants.

TABLE 27.1

Location of Purchasing Department (by Percentages) in Concerns with a Single Plant or Localized Plants *

Size of Organization	President	General or Plant Manager, etc.	Vice-President	Treasurer	Secretary	Executive Committee	Comptroller
Small	38	32	17	6	..	3	4
Medium	38	27	20	12	2	1	..
Large	17	50	17	..	16	..	..
All reporting with single plant or local plants	37	30	18	9	2	2	2

* Courtesy, National Association of Purchasing Agents, *Handbook of Purchasing Policies and Procedures*, New York, 1939, Vol. 1, p. 4.

TABLE 27.2

LOCATION OF PURCHASING DEPARTMENT (BY PERCENTAGES) IN CONCERNS WITH SCATTERED PLANTS *

Size of Organization	President	General or Plant Manager, etc.	Vice-President	Treasurer	Secretary	Executive Committee	Comptroller
Small	26	37	21	10	..	6	..
Medium	34	21	41	1	..	3	..
Large	50	17	25	..	..	8	..
All reporting with scattered plants	36	23	33	3	0	5	0
All reporting	37	27	25	6	1	3	1

* Courtesy, National Association of Purchasing Agents, *Handbook of Purchasing Policies and Procedures*, New York, 1939, Vol. 1, p. 4.

It sometimes happens that the purchasing end of a business is directly subsidiary to the selling end, or at least they go hand in hand. Such a situation always exists in a manufacturing concern where there is a quick turnover of all raw material that is purchased, with only a slight manufacturing process to be performed. This frequently occurs in markets which are highly organized, such as the cotton or flour market. In these cases and others, where "hedging" is carried on as a protection from loss, it is practically essential that the sales and purchasing phases of the business be under the same direct control. Of course, this does not apply to the purchasing of supplies. An example of such a situation is to be found in the business of mercerizing cotton yarns, where the yarns are frequently bought and sold within a few minutes' time, and the mercerizing process, which is all that is performed by the plant, adds but little to the value of the product.

There are many other types of businesses in which the manufacturing operations are more involved and relatively more important, but in which the position of the purchasing department is of maximum importance. Such businesses include most of the needle trades which purchase expensive fabrics, such as the men's clothing industry. In such business a very large share of the profit made during the year is derived from purchases at the right time or of exactly the right materials. Thus the cost of the material purchased is an important consideration in the authority granted the department.

Decisions must be continually made whether to buy or make a certain part. The answer in any given case is likely to be influenced by the state of the market at the time and the manufacturing conditions in the shop,

both in regard to the need for the product and the possibility of putting it through production and in regard to the desire to build up outside sources of supply to fill future needs. General executives sometimes feel that they are the only ones who can decide such questions. If the purchasing agent is competent and if a committee organization with a main factory committee is provided, such matters form an excellent subject for decision by these persons. The purchasing agent can be advised under such circumstances by the factory and design representatives who may be present.

In the main in a modern organization the purchasing agent works toward the quality specified by the engineering or design department and the quantity specified by the production or planning organization. Most purchases will originate through the inventory control that is maintained at the balance-of-stores desk, and this control will usually be exercised from the planning department. Regardless of the position of the purchasing department in the factory, some means should always be provided for keeping the head of that department closely in touch with all conditions that may influence the course of his daily task, at least in the immediate future.

Organization of the purchasing department. The specific organization of a given purchasing department depends largely upon the detailed functions of the department.

In this phase of organization, as in many others, the relative strength of individuals frequently influences the organizational structure. All too often a strong master mechanic buys not only his machinery but the supplies as well. There is good reason for him to specify certain qualities desired or even specific products, but there is little justification for his spending valuable time purchasing materials the specifications of which have already been determined. This does not mean that he should never see salesmen with new products unfamiliar to him. Sound purchasing practice will bring the master mechanic into all decisions involving technical matters concerning which he is particularly qualified. To have purchasing carried on by every man who has a special interest, however, violates the fundamental principle of functionalization. Purchasing by department heads usually results in payment of a higher price than is necessary and frequently is conducive to the placing of orders more on the basis of personal likes and dislikes than on the merits of competing products. Such practices may readily lead to direct or indirect bribery. Centralizing purchasing in the purchasing department will not eliminate the temptation to accept bribes, but it reduces the number of places in which this practice is possible. Purchasing involves much clerical detail

that is usually distasteful to most department heads, who tend to neglect it when they do the purchasing.

The internal organization of the purchasing department is greatly influenced by the size of the enterprise and the nature of the items bought. At the head of the purchasing department is usually a purchasing agent. He may answer to the president or, in larger organizations, to a purchasing committee. His title may be vice-president in charge of purchasing, director of purchases, purchasing agent, or something similar. In medium-sized organizations the purchasing officer may occupy the same high position that he holds in the larger organizations; however, he more frequently reports to the general manager. As organizations decrease in size, the purchasing department tends to be placed in a relatively less important position. It is not infrequent in the smaller organizations to combine purchasing and stores keeping. In smaller organizations there will usually be only one buyer, who may divide his time with some other duty. As the duties expand with increasing size of organization, more people are needed in the purchasing department. In the larger purchasing departments a high degree of functionalization takes place. Such organizations usually have a purchasing agent, assistant purchasing agent, buyers, file and record clerks, stenographers and typists, traffic division, follow-up division, and materials engineer, in accordance with the size and magnitude of the work performed. Where the volume justifies specialization, one buyer will purchase certain materials, and another buyer something else. There may be separate buyers for coal, lumber, steel, small tools and supplies, rubber, chemicals, and other items. The purchasing department is a functional department itself but usually is organized on a line and staff basis within the department.

Figures 27.1 and 27.2 illustrate two general types of purchasing organizations. In Fig. 27.1 receiving, stores, salvage, and inspection of incoming material come under the purchasing department. In Fig. 27.2 the purchasing agent directs only the buying and the clerical details pertaining to the buying. Inspection, receiving, stores keeping, and similar activities are handled by the operating departments. The author knows of one large metal-working company having six plants that has production control under the purchasing department in addition to the divisions shown in Fig. 27.1. This set-up is unusual, but it is purely a manifestation of the influence of personalities. In this company the purchasing agent is a vice president.

Table 27.3 shows the distribution of the source of requisitions. It will be observed that the purchasing agent initiates very few requisitions.

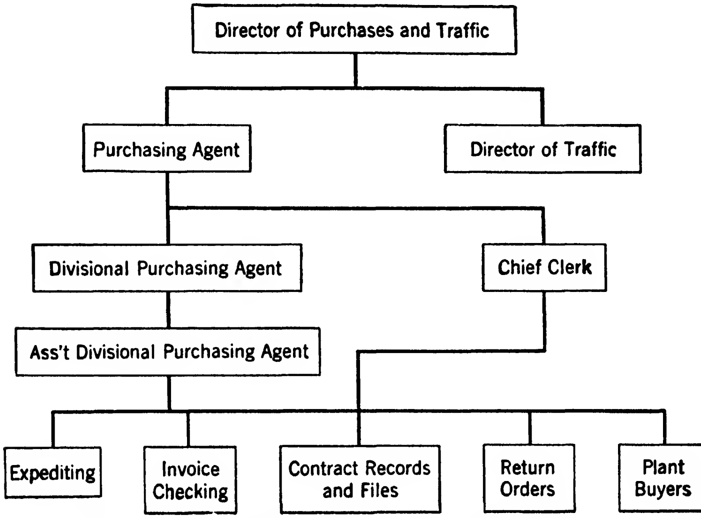


FIG. 27.1. Organization chart of purchasing department.

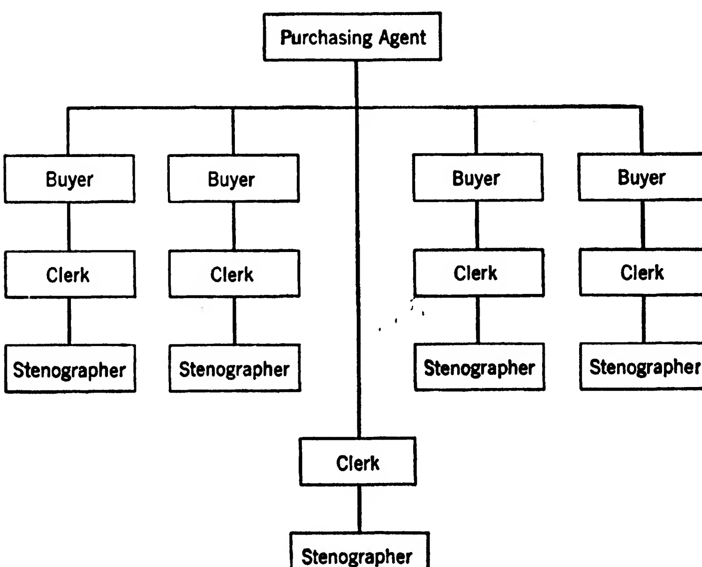


FIG. 27.2. Organization chart of the purchasing department of a glassware manufacturer.

TABLE 27.3

SOURCE (BY PERCENTAGES) OF INITIATION OF PURCHASE REQUISITIONS *

Size of Organization	Department Heads	Storeroom	Production Department	Superintendent	Executive	Purchasing Agent
Small	66	..	17	17	..	..
Medium	56	21	9	8	5	1
Large	64	23	8	2	2	1
All reporting	62	21	9	4	3	1

* Courtesy, National Association of Purchasing Agents, *Handbook of Purchasing Policies and Procedures*, New York, 1939, Vol. 2, p. 4.

Centralized versus decentralized purchasing. In large companies having plants in different locations the question of central buying versus local buying must be settled. This same situation within a given plant has been discussed under Organization of the Purchasing Department. The phrase popularized by the General Motors Corporation, "decentralized responsibility with coordinated control," sheds some light upon the philosophy of this company in solving this organizational problem. It is the policy of General Motors to buy centrally those major items which can best be purchased by the parent organization. When these items are not centrally purchased, they usually are bought by the main purchasing unit of the divisions. Many of the divisions have two or more plants, and the less important items frequently are purchased by the local plant when this is advantageous. The same situation is found in the big rubber companies. For instance, it would be absurd for each of the plants of the United States Rubber Company to buy its crude rubber independently. Similarly, to buy compounding ingredients and fabric independently would most certainly involve inventories in excess of need, and the prices paid by each unit would tend to be greater than the price paid by the central purchasing department. A higher degree of specialization in purchasing is possible when buying is done centrally than when many different buyers are purchasing the same item in many locations. Central purchasing also facilitates the transfer of excess stocks of a material from one plant to another. Better financial control is exercised when the major items are purchased centrally. Coordination may be maintained by having the central purchasing department prescribe the general routine and procedures but permit the local unit to exercise discretion in purely local matters. Where necessary or advantageous, all bills may be sent to the central purchasing department, where they are

checked and approved for payment by a central agency. This practice frequently involves extra clerical work and expense. No fixed rule for satisfactory purchasing is applicable to all organizations. Purchasing, like other functions of a business enterprise, must remain flexible in order to meet changing conditions.

Authority of the purchasing department. Authority usually develops out of the place of the purchasing department in the organization; or reciprocally, the authority of the purchasing department influences the position assigned to it in the organization. The authority of the purchasing department over finances must be limited. This department should be operated on some sort of budget system, whether or not this system has been adopted for the company as a whole. To require that all purchases be approved by the financial management of the concern too seriously limits the operation of the purchasing department, but to allow this department to purchase regardless of the condition of the finances is manifestly impossible. The most effective means of controlling the financial end of purchasing is through the operation of a general budget. However, if there is no general budget, very effective purchasing budgets may be set up which will prevent inventories from mounting through improper purchasing operations or through mistakes in running balance-of-stores sheets.

Sometimes, if a product is standard, the purchasing department is allowed to buy on the basis of the normal consumption for a given period, for instance, three months. After this point further purchases can be made only on an allotment of additional funds from the financial department. In unstandardized lines, the purchasing department is given a budget of so many dollars per month, from which it can buy any and every type of material up to the total of moneys so allotted. After the department has reached this point, it must seek further authorization before buying more. Either of these budget methods forces the purchasing agent to keep very close watch on his finances so that he will be able to purchase necessary items toward the end of his budget period.

Purchasing policies. Policy determination is the function of the major executives. An active purchasing agent should participate in the formulation of purchasing policies and may initiate many of them. Such decisions as whether to operate on a purchasing budget, to buy or to manufacture a given article, to engage in speculative purchasing or hand-to-mouth buying, or to substitute one material for another involve other departments and cannot safely be made except through the cooperative effort of the major executives concerned. Certain other matters, such as whether to ask for competitive bids, to place the order with the lowest bidder, or to divide a large order even though one supplier may be able

to fill it, involve borderline decisions and may or may not be left to the discretion of the purchasing department. A properly organized department, however, may well make these decisions. The internal organization of the purchasing department, in keeping with the organization structure of the enterprise as a whole, may well be left to the department head.

Reciprocal purchasing is one of the most annoying practices encountered by an efficient purchasing agent. Reciprocal buying refers to the practice of buying a given product because the vendor also buys the product made by the purchasing agent's firm. It is the old political game of "You scratch my back and I'll scratch yours" and is completely obnoxious to the capable purchasing agent. During periods of prosperity reciprocal buying recedes into the background. When sales are hard to make, pressure is frequently exerted to get the purchasing agent to "remember that we are one of your best customers." There is of course no criticism of the purchase of a product from a customer when his price is right and his product is the one desired. Under these circumstances the purchase would be made even though the vendor were not a customer. This is straight purchasing on merit and is not classified as reciprocal purchasing.

Hand-to-mouth buying. Hand-to-mouth buying came into favor after the depression of 1920. In reality it is a method of guarding against being caught with large inventories on a declining market. It is sound economics when not carried to the extreme. The practice has both social and economic advantages and disadvantages. Some of the *advantages* claimed by the advocates of hand-to-mouth buying are as follows:

1. Hand-to-mouth buying reduces the inventory of materials on hand and releases the capital that would be tied up for other productive purposes.
2. Storage facilities, storage costs, and handling costs are reduced when deliveries are timed so that the material may go directly to production. (One purchasing agent for an automobile manufacturer boasted that his materials came in the receiving door and did not stop until they came off the assembly line as part of the finished car.)
3. The budgetary requirements of production are more easily synchronized with purchasing.
4. The buyer and the seller have more frequent contacts and thus are enabled to work more closely together to the mutual advantage of both.
5. Losses arising from a decline in price are minimized by the buyer. (On the other hand, he may pay a higher price for his annual consumption during a period of rising prices.)
6. The buyer is in a position to take advantage of any favorable situation arising in the current market.
7. The buying organization is in a more flexible situation in that it may make changes in the design and nature of its product or adopt new or substitute materials more readily.

8. Hand-to-mouth buying should tend to level out production, since the producers have a better check on requirements than when the consumers buy in quantities and store a large part of their requirements. (This claim is true only in part, depending somewhat on the product. Since the practice has been adopted by the householder in buying coal, it has tended to increase the seasonal fluctuation because the producer cannot store his coal in the summer, nor can the coal yards absorb all the storage.)

A few of the many disadvantages of hand-to-mouth buying are as follows:

1. The producers are required to keep larger inventories, since the buyers rely upon the producers to carry the reserve inventories for them. (The grand total social or economic inventories are less, but the producer's inventories are greater.)
2. Unit purchasing costs on the hand-to-mouth basis are higher because of the failure to take advantage of quantity discounts.
3. Distribution costs are higher because of: (a) a larger number of sales to accomplish the same results—the actual cost of making a large sale is very little, if any, greater than for a small one; and (b) increased packaging cost, order-filling cost, and transportation cost when in less-than-carload lots.
4. In some instances seasonal peaks and valleys are increased.
5. The buying public, the individual consuming citizens, do not usually get as good service when the manufacturer of the original articles carries the inventories, especially when the retailers also buy on a hand-to-mouth basis. Often the manufacturer cannot take care of sudden increases in demand, for his inventories are not large enough to absorb this increase. Where buying for stock is more general, the grand total inventory in existence is greater, and consumer demand can be met more readily.

A compromise between hand-to-mouth buying and buying for stock seems to be more desirable than either practice to the exclusion of the other. Maximum and minimum stock-ordering points may be increased during periods of rising demand and lowered during periods of relatively slow or decreasing demand. This statement does not imply speculative buying. When a budget is being used, an anticipated requirement for three months may reasonably be determined. The full amount may not be bought at once, but purchases will certainly not approach the hand-to-mouth basis. Larger orders may be placed with provisions for price adjustment in case of a decline and shipping instructions to be issued as required. Such a procedure has advantages for both buyer and seller in the long run.

Methods of buying. There have been various classifications of the different methods of buying. Alford lists the following seven methods of purchasing:

1. Purchasing strictly by requirement.
2. Purchasing for a specified future period.
3. Market purchasing.

4. Speculative purchasing.
5. Contract purchasing.
6. Group purchasing of small items.
7. Scheduled purchasing.[1]

To purchase by *requirement* is to purchase only when needed and in quantities needed. Such goods as are purchased by requirement are usually not purchased regularly but are bought to meet a specific emergency need. The outstanding function of the purchasing department in this type of buying is to know the resources of reliable firms.

Supplies are often bought for *specified future periods.* These items are standardized products that are bought regularly but in relatively small quantities. The period covered by such purchasing is not fixed even for the same general class of materials. Operating conditions, quantities required, and the same basic factors that influence other types of purchasing are controlling.

Market purchasing seeks to take advantage of price fluctuations. It involves careful study of general market trends and the purchase of materials that are required in the light of reasonable market expectations. Utilities and manufacturing enterprises that can predict their requirements with reasonable certainty may safely engage in market purchasing and still not be directly involved in speculative purchasing. Raw materials such as rubber, coal, coke, and pig iron are frequently purchased on this basis. Market purchasing is definitely associated with planned production schedules, whereas speculative purchasing gives less attention to production requirements and is based largely upon expected changes in the market price.

Speculative purchasing is engaged in extensively by manufacturers or users of cotton cloth and also in recent years by users of silver. It is not unusual to have the major profit arise from speculative buying. The corollary, of course, is that production operations may be efficient, yet losses may be sustained because of errors in judgment in speculative purchasing. A major executive usually directs speculative buying. In reality speculative buying is a business within itself and may saddle production with costs that the producing group has no method of meeting. Obsolescence, demand for excess storage space and handling, and uncertainty as to available material when needed are among the problems that the manufacturing group must contend with when speculative buying is the practice.

Contract purchasing, as the name implies, is the purchasing under contract, usually formal, of needed materials, the delivery of which is

[1] L. P. Alford, *Cost and Production Handbook,* Ronald Press Company, New York, 1937, p. 360.

frequently spread over a period of time. Under circumstances when prices are uncertain, such as during 1933 and 1946, coal has been purchased on this basis with a variable price per ton, depending upon the wage paid the miners, inserted in the contract. Such provisions are not usually included in such contracts, however, because they defeat one of the major advantages from the buyer's standpoint, namely, taking advantage of low market prices to contract for requirements for a specified period.

Group purchasing seeks to take advantage of the savings that naturally accrue through placing one order for a number of small items rather than placing a large number of small orders. Group purchasing reduces the cost to the buyer by eliminating much clerical work and also saves the vendor a great deal of clerical detail and delivery costs. The balance-of-stores clerk or other person placing requisitions with the purchasing department can be of real service in grouping these requisitions. The purchasing department should re-examine group purchases from time to time to make certain that particular items should be included. Failure to make such a check constitutes a real danger in group purchasing.

Scheduled purchasing is closely related to carefully controlled production. It extends to the vendors some of the advantages of production control within the plant and thus enables them to plan their production and control their quality more effectively. Scheduled purchasing tends to reduce the inventories carried by the buyer and permits the vendor to control his inventories more closely, since he is not placed in the position of having to meet unexpected demands. Scheduled buying requires good faith and active cooperation on the part of both buyer and seller. On the other hand, scheduled purchasing tends to promote this good faith.

Purchasing specifications. The requirements of the design or engineering department must govern the quality of materials or parts, and yet the specifications must be in accordance with trade practice and trade terms. Specifications are most essential, if the product is to be standard and if bids are to be asked for and compared. Much of the secret of good purchasing lies in drawing good specifications which vendors must meet. This practice is a real money-saver, because it prevents a concern from paying for a brand or trademark name which has been built up at high advertising cost, when the same article can be purchased elsewhere at less cost. In addition, purchases may be made on a level of quality which is just good enough but not too good for the purpose at hand. Purchasing on specification is not particularly popular with vendors who include in their regular selling price the cost of establishing their trademark, but all companies, no matter how small, can use it. The only

requirements are care in setting the specifications and in inspecting goods upon arrival.

At times specifications may well be modified to fit the goods available. Thus slight and unimportant modifications of specifications may bring considerable reductions in quoted prices because the revised specifications will fall within the standard output of one or more of the vendors. Sometimes specifications are determined not by the buyer or by the vendor, but by the market. This is particularly true with those commodities which are subject to wide quotation, such as raw cotton, staple cotton yarns and cloth, and lumber. In such cases the purchasing department can only determine the grade to be bought and then see that the commodity as delivered falls within the market regulations for the grade ordered.

In some organizations the engineering department determines specifications. Even in this type of organization the purchasing department has an interest in the specifications and frequently makes suggestions that result in large savings in purchasing. It is apparent that under such circumstances the purchasing agent must have a good technical background.

Selecting the sources of supply. The successful purchasing agent strives to maintain friendly contacts with a number of suppliers. Inviting competition is the surest way of securing the best possible prices. The door of the purchasing agent's office should be open to any salesman who desires to see him. To give the impression that only a few favored salesmen are welcome is to stifle competition and ultimately bring high prices. Salesmen trained in their product should have ideas which are valuable to the purchasing agent and to the concern which he represents. To win the favor of as many vendors' representatives as possible is to have these men working for the interests of the plant also.

In this way the purchasing agent should be in constant touch with the newer developments of the trade. He can be of invaluable aid to his company, particularly the engineering or design department, through not only his judicious placing of orders but also his knowledge of trade conditions.

Initiating the purchasing requisition. Figure 5.2, p. 63, illustrates the path of a purchase requisition in a manufacturing company. For record purposes regular materials used in production are usually under the control of a balance-in-stores ledger clerk. The functions of this individual are strictly clerical and not policy-determining. He operates within certain carefully prescribed limits. If minimum ordering points have been determined and maximum ordering quantities fixed, this clerk fills out a requisition when the ordering point is reached. This requisition may

be sent to the superintendent, general manager, or production-control department, or directly to the purchasing department, depending upon the procedure previously determined and the department supervising the balance-in-stores ledger clerk. For maintenance supplies the order may originate with the maintenance department if these materials are not under the control of the balance-in-stores clerk. For engineering or technical materials the order usually originates in the engineering department. If central purchasing is practiced, these orders are sent to the purchasing department regardless of the person taking the initiative in starting the order. It is not at all unusual for the purchasing department to have to ask for additional information from the department requesting the material even though the order may have originally been filled out by a technical expert. A common oversight of this type is for the maintenance department to fail to give the serial number of a machine for which it is ordering replacement parts.

Securing quotations or bids. For certain standard items purchased in large quantities or other items purchased according to specifications it is often advantageous to secure quotations, and securing these quotations is primarily a function of the purchasing department. The purchasing department sends to a selected list of suppliers a request for a quotation for the specific articles or materials, giving detailed information or specifications, the quantities desired, the delivery schedule expected, and practically all the other information found on the regular purchase order. A special form that cannot easily be misinterpreted for an order is generally used for requesting quotations. When the quotations are received and prices compared, the order is usually given to the lowest bidder who can meet the requirements laid down. When the purchasing department is functioning properly, the order usually will go to the lowest bidder, since the department will not request a bid from an unreliable supplier. A matter of business ethics is involved in the handling of quotations. Under no circumstances should a competing vendor be permitted to see the quotation of another and then revise his quotation to underbid him. A buyer who follows such practices is sooner or later found out and pays a heavy price for his unfairness.

Placing the order. Whether the item is large or small, it should be purchased by using a purchase order (see Fig. 27.3). This order will serve for record purposes if nothing else. Such items as a single bolt may be bought out of petty cash, but these tiny purchases are relatively infrequent in an industrial enterprise. The purchase order is usually made out with two or more copies, the exact number depending upon the needs of the organization. Some of the uses for various copies are as follows:

In writing us please show our postal delivery zone number, as follows

A. B. DICK COMPANY

720 WEST JACKSON BOULEVARD
CHICAGO 6, ILLINOIS
Telephone Monroe 7460

PURCHASE ORDER

Invoices for goods delivered or services rendered on this order must bear a certificate that the prices charged are not in excess of legal maximums as established by the Office of Price Administration.

ORDER NUMBER
No. 000500
must appear on all
INVOICES, PACKAGES, SHIPPING MEMORANDA and CORRESPONDENCE

Date 1/10/44

Perfect Purchase Order Company
720 West Jackson Blvd.
Chicago, Illinois

F.O.B. Chicago, Ill. *Ship Via* Interstate Motor Freight System

Terms Net 30 days

Items requested hereon must be delivered to our plant at 719 West Quincy Street as follows:

14,500 Pieces-Part #99223-Long Pinion
To conform to complete specification as shown
on drawing attached.

1000-5/15/44
1100-6/15/44
1100-7/15/44
1200-8/15/44
1400-9/15/44
1600-10/15/44
1800-11/15/44
2000-12/15/44
2000-1/15/45
1000-2/15/45

SAMPLE

Price $1.50 each

The items covered by this Purchase Order are for use under Contract No. G-442-AB-22 for the war program.
Acceptance of this Order constitutes an acceptance of the terms and conditions, 1 through 14, set forth on the back of this instrument.

C.M.P. Allotment Symbol T-3-15
T-3-16

Priority Rating AA-1

Aluminum Rod
Bar & Wire &
Cable
330 lbs.
100 lbs.

The undersigned purchaser certifies, subject to the penalties of Section 35 (A) of the United States Criminal Code, to the seller and to the War Production Board, that, to the best of his knowledge and belief, the undersigned is authorized under applicable War Production Board regulations or orders to place this delivery order to receive the item (s) ordered for the purpose for which ordered, and to use any preference rating or allotment number or symbol which the undersigned has placed on this order.

A. B. DICK COMPANY

By ______________________
Purchasing Agent

If above items cannot be delivered to our plant within three days, the attached order acceptance form must be executed and returned immediately.

A. B. DICK COMPANY

By ______________________
Purchasing Agent

FIG. 27.3. A sample purchase order.

1. Original or vendor's copy is sent to the vendor.
2. A copy is kept in the purchasing department and filed numerically by the order number for ready reference.
3. A copy is sent to the receiving department as a notification to be on the lookout for the material.
4. A copy is sent to the department initiating the order.
5. A copy is sent to the accounting department.
6. A copy is sent to the follow-up clerk or division of the purchasing department.
7. A copy is sent to the inspection department.

Few organizations use all seven copies, but nearly all of them, except the very small ones, use at least two or more, frequently three.

The purchase order is a very important document and should be so drawn that misunderstandings are not likely to arise. It should include the following details in addition to the firm's name and the date:

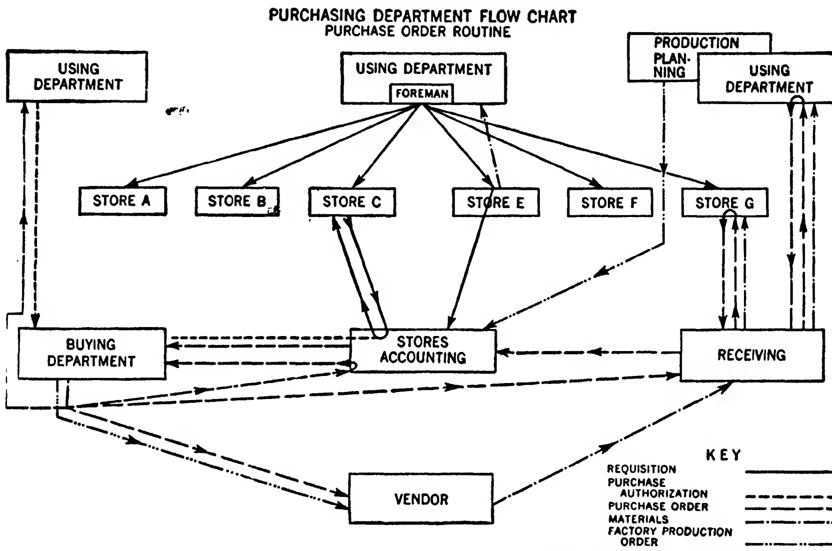
1. Purchase order number to be used by the vendor in billing and shipping the material.
2. Quantity of material ordered, expressed in terms commonly used for this purpose.
3. Description of the material ordered in detail so that there can be no chance of error. This description should be in terms of standard specifications where possible.
4. Delivery date requested.
5. Detailed shipping instructions: the place to be shipped to, the method of shipment when there is a definite preference, kind of packaging, etc. If these items are omitted, the vendor will follow his own interests, which may not be in keeping with the desires of the purchaser.
6. Billing instructions.
7. Price, when an agreed price has been established.
8. Terms, when these have been agreed upon.
9. Any other item of importance, such as protection against damages arising from patent infringements.

Figure 27.4 illustrates the routing of a purchase order in a manufacturing company. It should not be inferred that all companies use the same procedure. Frequently the methods or procedure department may increase the efficiency of the purchasing procedure by making a careful analysis of the current practice.

In placing orders it is essential that the purchasing agent know the general market level of prices, as well as the prices which he is being asked for particular materials. This information will enable him to appraise the quotations which he receives. He must also have a thorough knowledge of discounts and datings current in the trade at the time. Frequently, although reductions from list prices cannot be secured, the same effect may be gained by an increase in the discount for cash. Particularly in times of tight money, alert purchasing agents can reduce the cost of purchases materially by this means. In order to know when to

place orders, the purchasing agent must have a background knowledge of general business conditions. If he is not to fear quickly rising or quickly falling markets, he must study trade reports and general reports of business conditions; these are readily available.

The purchasing agent who gives the vendor the most consideration on delivery dates will secure the most favors in the long run. Some pur-



Courtesy, National Association of Purchasing Agents, "Handbook of Purchasing Policies and Procedures," New York, 1939, Vol. II, page 34

FIG. 27.4. Routing of purchase orders in a manufacturing company.

chasing departments have built up reputations for always putting the word "Rush" on orders. If records of stores are properly maintained, there will usually be no reason for asking vendors to rush most of their orders, and proper delivery dates can readily be set.

Some general managers keep careful watch over the relations of purchasing agents and vendors, for the reason that the purchasing agent represents the company before a large portion of the business world, and that the impression which the trade will get of the company and its policies will be determined largely by the actions of the purchasing agent. Some companies will not allow the purchasing department to let contracts to anyone but the lowest bidder without first consulting some designated member of the general management.

Follow-up, receiving, and inspection. The exact nature of the follow-up depends largely upon circumstances. Often a telephone call is

sufficient. Again, the situation may require a more detailed report by letter or an inspection trip through the supplier's plant. When traffic jams occur at central rail-distributing yards such as those in Toledo, Ohio, and Russel, Kentucky, the follow-up man may have to go out in the yards, locate the car having his material in it, and bring pressure to bear upon the yard master to move the car. In other words, a good follow-up man must be versatile and must be prepared to do anything reasonable to get his purchases delivered on time to meet production needs.

Receiving may or may not be under the direct control of the purchasing department. It is essential that the receiving department notify the purchasing department of the receipt of all purchases, as well as the count and the condition of the material when received. If there is a separate inspection section for the receiving department, this division reports on the quality of the goods received and at times on the count. Either the receiving or the inspection department must notify the purchasing department regarding the count and the condition of material received so that the purchasing department can approve the invoice for payment. The copy of the purchase order sent to the receiving department may be returned to the purchasing department with the correct count and the condition of material noted on it, or this same information may be given the purchasing department on a special inspection or receiving report.

Purchasing records. Records of past transactions, as well as of current ones, are vital to intelligent purchasing. In almost no other place in management are records of what has previously happened more vital. Information files, with complete and detailed data concerning materials and vendors, are the very backbone of the purchasing department.

One of the more important types of information which should be readily accessible is a list of manufacturers, dealers, or jobbers who are in a position to supply the articles which are regularly used or who may be considered prospective bidders on any special commodities which may be required from time to time. All such information should be complete to be of maximum value. It should include the location of the plant and the sales offices, the names of the persons to be dealt with, the freight rates, any necessary remarks concerning the freight situation between the point of shipment and the plant, such as congested junction points which may delay the shipment, and a notation of whether the concern is in a position to fill orders from stock or must manufacture them to order. Other items of interest on these firm record cards should be facts regarding the manufacturing capacity or usual supplying capacity of the firm and the maximum size of the orders that they can handle. Catalogues may be arranged by cross reference to this list.

A quotation file which will have readily available past quotations by both successful and unsuccessful bidders should be maintained. Such a file will ordinarily be composed of the returned "request for quotations," which have been sent out originally by the purchasing department, and will be valuable in checking over any new quotations which may be received, in settling disputes concerning reasons for granting previous orders to other bidders, and in providing a general bird's-eye view of the policy of the purchasing department with reference to the concerns which are invited to bid. This quotation file gives the complete history of all orders on which bids have been requested before the actual filing of any of these orders. The next group of records, the actual purchase records, may duplicate some of this information, but this duplication will not be harmful, inasmuch as when the information is wanted it will be most easily found as a quotation or as a purchase order, depending on the need at that particular time.

Purchase records are usually maintained in three ways in most effectively run departments, namely, by firm name, by articles, and by purchase orders. The purchase records by firms include a sort of account for each firm with whom business is carried on. This record is used to check over receipts and invoices, as well as serving as a record on which to base the issuance of future business. In maintaining this record of purchases by firms it is most essential that all discounts and datings be carefully noted, as these will serve as a check when purchases are next made from the company in question and are quite as important as the quoted sales prices.

Purchase records by articles are useful in showing the trends of prices and in discovering whether bids that are received are high or low, particularly on commodities and articles for which there is usually no stated "market." One error which is frequently encountered in this type of record and which must be guarded against is the placing of dissimilar commodities on the same card because of the incomplete description which is on the card or on the purchase order. This is just one more reason for making purchase orders extremely explicit. Slight differences in the article ordered may make the record of purchase by articles show fluctuations which are not at all justified.

Purchase records are usually maintained in all purchasing departments by purchase order number, if in no other way. All shipments must ordinarily be marked with the purchase order number, and incoming goods are checked against the purchase order by the purchasing department before it approves the invoice and sends it to the accounting department for payment. This type of purchase record usually consists of a retained copy of the purchase order, a copy which ordinarily has spaces

for office records not appearing on the original of the order that goes to the vendor. Such notations include, "approved for payment," "expense distribution," "partial receipt."

Another type of record which greatly increases the effectiveness of the operation of the purchasing department is the tickler follow-up of orders outstanding. This consists merely of a file, wherein special copies of the orders or separate slips bearing the order number are placed, to be called to the attention of the designated person at a stated date after the papers are placed in the file. By calling orders to the attention of a member of the purchasing staff at certain periods before the material is actually needed in the factory, it is possible to make certain that the material will be on hand when wanted, or at least that extra effort may be made by the purchasing department to secure it by the proper time.

CHAPTER 28

CONTROL THROUGH THE USE OF THE BUDGET

Historical background of the budget. In this country budgets were first extensively used in connection with local governmental bodies. Later their use spread to counties, states, and eventually in 1921 to the federal government. It was simple for the governmental bodies to adopt budgets because the income could be estimated fairly accurately. The application of the budget amounted largely to a parcelling-out of the estimated receipts among the various agencies.

Because of the difficulty of estimating the income of business concerns, not very extensive use was made of budgets until the publication of a book by J. O. McKinsey in 1922. Once the application and practicality of budgets were demonstrated, great numbers of industrialists were won over to their use.

Early budgeting applied principally to expense, but it was soon expanded to cover sales, production, plant additions and changes, and revenue. The success of the firms which applied it correctly encouraged others to try it, and soon budgeting had undergone an amazing development in business.

The nature of a budget. Most authorities agree that the function of a major executive is to plan, organize, and control. Control is the prime objective of budgeting. Control over the operation of a particular department of a business is difficult to maintain unless it is associated with a corresponding control over departments with which it must work in the drive toward business progress. A device for providing this control is the business budget, which has been variously described as:

1. A method of rationalization whereby—

(BUDGET) $\left\{\right.$ estimates covering different periods of time are by the study of statistical records and analytical research of all kinds, established for all and everything affecting the life of a business concern which it is possible to express in figures.

(Control) { These established standards are constantly revised and checked for the periods determined in the light of actual achievement, with the double purpose of correcting the estimates, and of initiating the investigation and correction of causes of discrepancies.[1]

2. An instrument tending to promote cooperation, coordination, and control.

3. . . . the word *budget* will be used to mean a particular form in which a sales forecast and plan of management may be expressed that will facilitate their use in management. The term *budgetary control* will be used to mean the way in which such a budget is used to organize, coordinate, and stimulate the activities of executives, and to control income and expense.[2]

The administrative budget provides the necessary means of supplying the coordination between departmental plans. The budget concept in business implies the idea of planning ahead, forecasting tomorrow, and coordinating plans so that the business will operate as a unified whole. Business foresight is largely hindsight, and thus administrative budgets must be developed not only by means of forecasts of business conditions as they affect the particular enterprise but also on the basis of past history, carefully interpreted. The form of a business budget, its complexity or simplicity, is determined largely by the purpose the budget is meant to serve and by the nature and type of the organization using it. Business budgets are much more difficult of formation than are governmental budgets, since income and expenditures cannot be separated. Unlike budgeting for governmental work, a reduction of expenditures in a business may lower the revenues directly. A reduction of an advertising expenditure may decrease the sales and hence the income, and the reduction of a manufacturing expenditure may directly affect production and hence the source from which income is derived.

Objectives of a business budget. Budgets provide for a careful item-by-item consideration of divisional and departmental programs. They become a check on unjustified optimism or pessimism of departmental heads. Not only does the budget make possible the development of departmental programs, but it is a means of curtailing overexpenditures in departments. Preconsideration of items of expenditure makes possible the recognition of leaks, both at the time the budget is being considered and during the period of operations that it covers. If expenditures for

[1] National Industrial Conference Board, "Budgetary Control in Manufacturing Industry," p. 11, quoting from an editorial in the *Bulletin of the International Management Institute,* July, 1930, Geneva.

[2] John H. Williams, *The Flexible Budget,* McGraw-Hill Book Company, New York, 1934, p. 4.

plant enlargement are subjected to a careful survey of their purposes and their justification, with a realization of what they will mean in terms of expansion of sales and production, it is very likely that hasty enlargement plans will be eliminated, and assets retained to carry on activities for which they are already needed. Bankers are steadily and increasingly demanding more knowledge of operations and programs than formerly. They are asking for information concerning not only balance sheets, character, and capacity but also prospective operations. In increasing numbers bankers are demanding submission of a budget which will definitely indicate when loans are going to be repaid, with substantiating figures, at the time when the application for a loan is made.

Planning the initial budget. The National Industrial Conference Board survey listed some eighteen mistakes or misunderstandings that companies have encountered with their budgetary programs.[3] The first eight of these mistakes indicate rather specifically conditions that might well have been considered before the original installation, namely:

1. Expected too much.
2. Installed too rapidly.
3. Inadequate supervision and administration.
4. Bad organization.
5. Inadequate accounting system.
6. Inadequate cost system.
7. Inadequate statistics of past operations.
8. Expected results too soon.

Advocates of budgetary control are often guilty of claiming too much for this tool, and the logical result is disappointment on the part of management. Furthermore this overexpectation may lead management to install the budget too rapidly. Even under favorable conditions the installation of a budget is an educational process. It requires time. The by-products of budgetary installation are frequently more important than the budget itself. Inadequate supervision and administration usually accompany failure by management to recognize the underlying significance of the budget. Budgeting cannot be reduced to a formula to be solved by a low-salaried clerk. It requires judgment of the highest order. It is better by far not to undertake the budgeting of an enterprise than to doom it to failure from the beginning by bad organization and inadequate supervision. The existence of factual data of past experience from which to construct the budget is essential. Unless the accounting system is so organized as to make possible the collection of information with which to fix specific responsibility, the budget should not be undertaken.

[3] National Industrial Conference Board, *op. cit.*, p. 16.

If the accounting system is not designed to provide these data, modification of it to make possible the current collection of the required information should precede any effort at budgetary control. What has been said regarding accounting is equally applicable to other statistical data that may not come directly under the accounting department.

It is highly essential that the performance of each budgetary unit be measured in terms of those items for which it can be legitimately held responsible. A preliminary consideration is the determination of those executive levels and individuals that are to be placed in charge of performance. The budget is then constructed to fix responsibility and to measure performance in terms of this responsibility.

Factors to be considered in constructing the current budget. Special planning before the construction of a given budget is an effective aid in formulating a workable budget. This planning should include all major policy changes as well as procedures that will influence operations for the budgetary period. A few of these major considerations are as follows:

1. The attitude of the management should be fairly clear with respect to the influence of the position in the business cycle. It is not possible to know exactly the movement that will take place; however, intelligent budgeting cannot be undertaken without careful consideration of the cyclical trend.
2. Modernization of production equipment should be considered, especially when such modernization will directly affect departmental budgets.
3. As far as is practicable, due consideration should be given to salary and wage changes that may be anticipated during the proposed budgetary period.
4. Plans for contraction or expansion of production should be noted. During every period some organizations are contracting, whereas others are expanding. This situation exists in periods of both depression and prosperity. A contracting program requires special care to avoid catastrophe. An expanding program also demands watchfulness to take full advantage of the opportunities offered. Formal declaration will tend to focus the entire organization's attention on such problems and thus will usually prevent the overlooking of some important item.
5. Policy concerning product change, development, or the introduction of new lines should be stated. Any major change will frequently make heavy demands on expenditures for equipment, advertising, and sales effort.

The extent and detail of budgeting will depend largely upon the magnitude of the enterprise and the relative experience of the management with budgets. By far the most common is the sales budget. In fact, in many industries the sales budget is the foundation upon which all budgeting depends. There are times and situations in which the sales budget is limited by the productive capacity or the financial budget; during normal business, however, experience has tended to emphasize the budgeting of sales first and then the construction of all other budgets in terms of anticipated sales.

The budget officer. The general manager or another major executive should be in charge of the budget. Regardless of the title of the officer or committee nominally in charge of the budget, the major executive officer is in reality the responsible budget officer. Good organization may necessitate the delegation to others of many of the routine phases of budget construction and operation, yet in the final analysis its success or failure rests on the shoulders of the chief executive. The actual amount of time that he must give the budget will depend largely upon the efficiency of the operating units and his immediate subordinates. This situation illustrates the *exception principle in management.*

TABLE 28.1

TITLES OF EXECUTIVES IN CHARGE OF BUDGETS * AS REPORTED BY NINETY-THREE COMPANIES

Number of Companies	Executives	Number of Companies	Executives
27	Comptroller	1	Statistician
24	Treasurer	1	General auditor
7	President	1	Superintendent of plant
5	Assistant treasurer	1	Comptroller of budget
4	General manager	1	Budget director
3	Assistant comptroller	1	Budget-control officer
3	Secretary	1	Manager control department
3	Budget supervisor	1	Manager of forecast and analysis department
2	Assistant to president		
2	Vice-president	1	Cost manager
2	Auditor	—	
2	Factory accountant	93	

* National Industrial Conference Board, *Budgetary Control in Manufacturing Industry,* National Industrial Conference Board, Inc., New York, 1931, p. 38.

The actual titles of the persons directly responsible for the supervision of the budgets in ninety-three companies surveyed by the National Industrial Conference Board are given in Table 28.1. It is not surprising that the comptroller and treasurer are named so frequently, since both these officers have access to many detailed records that are essential to effective budgeting. Both are likely to approach the budget more from the standpoint of records than of the fundamental conditions out of which the records grew. This fact has caused friction in many organizations. Such friction may be reduced by the use of an advisory budget committee composed of men who really know the operating conditions. The National Industrial Conference Board in its study found that out of ninety-five companies reporting, thirty-eight used budget committees.[4] Budget

[4] National Industrial Conference Board, *op. cit.,* p. 40.

committees, composed of operating executives, are valuable aids to budget officers in at least two major ways: (1) furnishing technical information necessary for intelligent interpretations of accumulated records; and (2) directing and supporting the budget officer in formulating and carrying out the budget.

Constructing the budget. The development of the budget usually starts with a preliminary conference of the major department heads, in which the trends of the business and of industry in general are considered, and broad lines of progress are mapped out with the aid of the general manager and others who formulate the basic policies of the business. If the controlling factor is the amount of goods that can be sold at a profit under competitive conditions, the first budget that must be constructed is the sales budget. This having been done, the departmental heads prepare budget estimates based on the general program that has been outlined. These budget estimates are usually submitted to one officer of the company, ordinarily the comptroller or the assistant to the general manager, who has been chosen for the purpose. Although the details of the budget may be delegated to a lesser official, in reality the general manager is the budget director, and the responsibility is his even though details may be handled by his representatives. In a small business the coordinating budget officer usually is the general manager. To the department heads he suggests changes based on his knowledge of broad factors and tending to coordinate the activities of the various departments. He may call conferences of two or more departmental heads whose estimates depend on each other but who appear to disagree in their first estimates. When such matters have been adjusted to the fullest degree by such conferences, a general budget meeting is called; at this time each department head submits his budget and must meet the criticism and comment of the others present. Although final control of the budget estimates must necessarily be left in the hands of the president or general manager, this meeting will ordinarily largely determine the final status of the budget. When finally determined, the budget should be prepared in a satisfactory form and distributed to all interested persons in order that they may know definitely what is expected of them.

If a budget is actually to control, rather than to be a hoped-for but impossible ideal, it must be flexible and elastic to meet variable conditions that may occur during the budget period. There are always some aspects of the future that cannot be forecast at the time the budget is prepared. These unpredictable factors include minor changes in general business conditions, although major swings of the pendulum should be visualized, such as changes in consumer demand. Changes in consumer demand may be basic, as a change in the type of material in fabrics, or they may

merely involve style, such as changes in the patterns, colors, or weights of a fabric. Modifications in sales and production schedules may have to be made on account of the unparalleled favor that is suddenly afforded one particular product.

Constructing the sales budget. If it is assumed that the production departments can turn out all the product that the sales department can sell, there are three primary approaches to the sales budget:

1. Each salesman throughout the country estimates the total sales by items that he thinks he reasonably can expect to make during the next budget period. These estimates are summarized by territories, and a sum total is drawn up for entire anticipated sales. Each salesman's estimate may be increased or decreased by his regional supervisor if the supervisor feels that the particular salesman is either too pessimistic or too optimistic. This estimate is a pragmatic one and has the advantage of being in effect a pledge on the part of the men actually in the field to perform.

2. The central statistical division, after having studied past performance of sales by items in relation to certain indices, may build up a scheme of forecasting sales either in terms of total volume or, better still, by products. By using regional information about the general economic situation, this total estimate may be broken down into estimates for localities. Certain industries have been experimenting with this method with considerable success. The outstanding problem is to find the proper index, especially one that anticipates performance.

3. A third method combines both of the foregoing ones. The statistical estimate is modified after being checked by the men in the field. This seems to be the most successful method. The sales department's estimate includes a full statement not only of necessary expenditures, but also of probable sales and shipments during the budget period, subdivided by kinds and unit value as well as by total value. The estimate of shipments is equally as important as that of sales, as upon it will largely depend the time when cash receipts may be expected. This estimate must be based on a consideration of past history, as well as of the seasonal factors that may be involved, the business and competitive conditions in the industry, the obsolescence or style factors which may be present, the traffic conditions, and the relation to the manufacturing program, both as regards production needs and the extent of unfilled orders. An important consideration is the available demand at various selling prices, with the margin of profit that is left under each condition. The cost of securing large volume, with full data from the manufacturing departments, will in great measure determine the output that the sales force will attempt to sell.

RECORDS AND COST CONTROL

The manufacturing budget. If standard articles are being manufactured, the number in each unit of time during the budget period may properly form the basis of the manufacturing budget, with all expenditures dependent on this budget. If, however, the concern works to the customer's order or is largely influenced in the exact amounts of different lines or styles that it manufactures by the day-to-day demands of the market, it is probable that the manufacturing schedule must be worked

out in terms of units of material or of cost. The manufacturing budget must be determined not alone from the estimated sales but also from the requirements of the manufacturing departments. An attempt must be made to run the plant on as even a keel as possible the year round, and the manufacturing budget, as well as the sales department's estimates and the financial requirements of the plant, must be developed with this purpose in mind. The unit costs of manufacture under varying amounts of production need to be closely studied by the manufacturing executives in order that they may intelligently make recommendations concerning the spread of the manufacturing program over the course of the budget period. In fact, efficient budgeting of production calls for a series of budgets at various productive levels. The manufacturing budget is, in other words, *a step budget* rather than a single budget for a given quantity. This aspect of budgetary control is possibly its greatest contribution to efficient management. It forces the persons responsible for decisions to think through the problem before it arises and thus insures prompt action when the budget is used effectively.

The estimated payroll can best be determined on the basis of prospective production by carefully analyzing past payrolls at various points of production, and from these figures making allowances based on changes in wage rates or in production effectiveness. A consideration of additional payroll costs due to overtime work or to the necessity of adding to the overhead will often serve as a means of stopping sales-expansion programs which otherwise appear desirable.

Among the factors which assist the manufacturing department in formulating its budget are the following:

1. Attempts to stabilize production through building up a finished-stock inventory during slack periods.
2. Development of supplementary products which will make possible a balanced production fully utilizing equipment.
3. Consideration of the desirability of manufacturing or purchasing component parts and facilities for storing materials.
4. A consideration of production costs of varying outputs.

Service departments' budgets. Although certain phases of maintenance and other services are relatively constant, others are closely related to the productive hours worked. The roof will need repairs and the buildings will need paint even though production approaches zero; however, the maintenance of machinery, sweeping of floors, and many other items can be made to approach the productive output. The budgets of the various plant service departments, such as traffic, shipping, and stores, may be included in the general manufacturing budget, or they may be developed separately, inasmuch as, like other service functions of the fac-

tory, the amounts of outlay for them are more or less constant, regardless of the manufacturing program. The budgets of the general business service departments, such as the general office and the personnel department, should be capable of close estimate and easy preparation by the heads of these departments.

The financial budget. There are situations in which the financial position may dictate all other budgetary programs. For example, it may be desirable to increase the inventory of finished goods, but this cannot be done unless funds are available to carry the additional inventory. The financial budget cannot be prepared until the other major departmental budgets are fairly near completion, since it is directly dependent upon them. The foregoing statement is true where the company is in a sound financial position and has ample credit facilities.

The financial budget should include a statement of the probable cash income and expenditures by months and a careful analysis of the times at which the company will be compelled to borrow in order to carry on its manufacturing program, as well as the times at which it may be expected that the loans will begin to be repaid and the times at which they may be completely repaid. The credit man of the organization will have a direct interest in the preparation of this information, and it will be his advice concerning collections that will make possible the translation of the items of shipments into receipts at a later time during the budget period. In addition, he must be able to advise the times at which overdue balances will be liquidated. This information will largely give the basis, together with the sales department estimates, of the expectancy in receipts. From the other budgets, cash outlays must be determined through a consideration of such separate items as materials, direct labor, overhead expenditures, administrative and selling expenses, state and federal taxes, fixed charges, and improvements to the plant. From the close analysis of all these items prospective balance sheets for various times during the forthcoming budget period may possibly be formed.

The budgetary period. The decision concerning the length of the budget period must depend partially on the extent of information which is available regarding past operations. As budgets are prepared and actual performance statistics become available to check against estimated figures, the length of the budget period may be increased. Some automobile manufacturers have a master budget covering the anticipated operations for the ensuing year's model. This master budget is broken down into a quarterly or a three-months' operating budget, which is the basis for some of the major purchases. The quarterly budget is broken down into a detailed operating budget of one month or, during slack periods, to ten-day releases and is revised at the end of each month in

the light of current performance. Such a budget is in reality a step budget that is carefully controlled in keeping with current performance.

General business conditions will also influence the length of time that the budget estimates should cover and the number of revisions that must be made. In different businesses the variations in the length of turnover of moneys and the importance of the seasonal factor will partially determine the length of the budget period. It should always be long enough to cover at least one complete cycle of operations, provided that seasonal features and manufacturing to stock in anticipation of later sales are important in the business.

Advantages and limitations of the budget. During the process of constructing the budget coordination of effort is secured. Each participant in the budgetary process is enabled to see how his department fits into the enterprise as a whole, as well as the many factors comprising his own department. In summary form the budget tends to secure the following actions or results, which are achieved either as a part of constructing the budget or in striving to meet the goals it establishes:

1. Analyzes all the factors affecting the departments and the business as a whole.
2. Harmonizes departmental programs.
3. Designates departmental and individual responsibilities and authority.
4. Provides management with a guide to daily activities and a means of control.
5. Serves as a medium of disseminating policies throughout the enterprise.
6. Serves as a restraint upon unwise expenditures.
7. Harmonizes sales and production programs.
8. Provides a strong incentive for the achievement of the established goal.
9. Provides a basis for measuring performance.
10. Tends to aid in stabilizing production.
11. Facilitates financial control.
12. Builds morale when operated in a truly managerial spirit. (It is highly important that the budget should not become a clerical instrument operated by an individual with only a clerical outlook.)

It must be understood thoroughly that budgeting cannot take the place of adequate executive control of operations; it is only an aid toward this function. The effectiveness of the budget is directly dependent on the effectiveness of administration within the several departments. It is an influence which should lead to better executive control but can never replace it.

CHAPTER 29

OPERATING A BUDGET

The budget in operation. Some managers recognize the need for an operating budget and initiate a program for its establishment without giving full support to its maintenance and use. There could be no more serious mistake. It is better by far never to start a budget than to let it drift and eventually be discarded as nonessential. To be effective the budget must remain dynamic. It can retain its dynamic features only when the general manager gives it his support and personally uses it in his contacts with his division heads.

Reports from other workers form the basis of the general manager's control of expenditures during a budget period. He should have information available at all times regarding the percentages by which each department is above or below its quota. If the operation of the budget is to be effective, he should question constantly with *wisdom* and *understanding* the figures that are appreciably out of line in either direction. Department managers must maintain similar checks on operations and expenditures within their departments. If department budgets are controlled effectively, there will be but little need for action on the part of the general manager or his budget officer.

An alternate budget may be prepared at the time that the budget is adopted and may supersede the one that is rendered out of date by changes in conditions. Such flexible budgets may be prepared departmentally; and, without further instruction, if departmental activities vary by certain percentages, the departments know the percentage by which they should increase or decrease their expenditures. If the costs of basic materials or of direct labor vary by specified percentages, definite predetermined authority may likewise be given the production departments to increase or decrease their expenditures in definitely stated proportions, and similar authority may be given the sales department to vary its estimated receipts from sales. It is at times more practical, however, to call for revisions of the budgets when basic conditions change.

General budgetary control. In large corporations, and even in smaller ones, provisions may be made for constructing monthly or quarterly balance sheets to compare with the budgeted balance sheet. The important

factor is that the original construction of the budget should provide the necessary tools for control. The basis for operating control through the budget is laid in the original construction of the budget itself. *Adequate accounting procedure must be provided to supply current data relative to the performance of each budgeted unit.* The organization must have been developed to the point that a specific person is charged with the responsibility for the performance of each departmental or divisional budget. Otherwise it will be better to postpone any attempt at budgeting, for confusion and overlapping of responsibilities are certain to arise. *Estimated costs of operating the major divisions must have been set up in keeping with expected sales volumes.*

The standard that acts as a guide for all budgetary control is the master budget for the period. Table 29.1 shows an annual budget for a machinery manufacturer. This master budget is broken down further into a monthly budget. It is desirable that top management receive a monthly report comparing the performance for the preceding month with the budgeted operations. This same monthly report should include a comparison of performance to date with the actual performance for the corresponding month of the previous year.

Major business control. It is difficult to visualize how modern business could be controlled with understanding and constructive foresight without the budget. When margins of profit are large, accuracy in control is not quite so essential. Today the difference between profit and loss is frequently dependent upon the accuracy and comprehensiveness of budgetary control. As the budget period progresses, the general manager must have accurate reports of operating conditions within the business. It is on the basis of these reports that changes in the budget will be made. Periodic reports, monthly or semimonthly, will inform him of the profits and sources of profits within the last period. These reports will be compared with past periods and with the budget. Such reports will include a statement of earnings, operating expenses, and profits for the month, as well as an income statement, which will be divided into budget accounts. Major expense headings will be given for each department, with comparisons with the budget.

Analysis of current business conditions. Various economic services are available to assist in forecasting business conditions. In addition to the commercial services, some of the more important sources of information are the statistical data of the Federal Reserve Banks, the reports of the Bureau of Labor Statistics and the Department of Commerce, the forecasts of the several university bureaus of business research, and independent statistical studies of business cycles.

TABLE 29.1

ESTIMATED ANNUAL SALES AND COST OF GOODS SOLD BY THE EVANSTON MACHINERY COMPANY

(Hypothetical figures, 000 omitted)

Products	Estimated Annual Sales	Cost of Goods Sold	Percentage Cost of Goods Sold	Direct Labor	Percentage of Direct Labor in Cost of Goods Sold	Direct Material	Percentage of Direct Material in Cost of Goods Sold	Burden (180% of Direct Labor)
Electric hoists								
Machines	$1,000	$ 560	56	$118	21	$ 230	41	$ 212
Parts	800	420	52	76	18	210	50	134
Resale	500	310	62	....	..	310	100	......
Total	2,300	1,290	56	194	..	750	...	346
Coal								
Machines	1,100	610	55	146	24	201	33	263
Parts	1,000	530	53	111	21	219	41	200
Resale	800	510	64	....	..	510	...	......
Total	2,900	1,650	57	257	..	930	...	463
Electric drills								
Machines	800	420	52	67	16	233	56	120
Parts	500	250	50	38	15	144	58	68
Resale	200	120	62	....	..	120	100	......
Total	1,500	790	53	105	..	497	...	188
Air drills								
Machines	900	460	51	69	15	267	58	124
Parts	700	350	49	49	14	213	61	88
Resale	400	260	66	....	..	260	100	......
Total	2,000	1,070	54	118	..	740	...	212
Gasoline compressors								
Machines	1,000	570	57	91	16	315	56	164
Parts	700	360	51	54	15	214	58	92
Resale	300	160	54	....	..	160	...	......
Total	2,000	1,090	55	145	..	689	...	256
Electric compressors								
Machines	800	450	56	81	18	225	50	144
Parts	400	220	55	35	16	123	56	62
Resale	600	320	53	....	..	320	...	......
Total	1,800	990	55	116	..	668	...	206
Special drills	500	350	70	....	..	350	...	......
Total for all products	$13,000	$7,230	56	$935	13	$4,624	64	$1,671

With the available business reports before him, the general manager may call his advisory committee to consider the major trends which they indicate. On the basis of their own knowledge of business conditions and that of any statistician or other advisory man with information of business trends, it is decided whether the budget shall continue as adopted for the remainder of the period or whether changes or a whole new budget shall be made.

Successful operation of a budget depends, above all, on effective control of the various departments of a business: sales, production, finance, and their several divisions.

Controlling the departmental budget. The success or failure of the institutional budget depends upon the effectiveness of the respective departments in meeting their budgets. Each department head not only must be familiar with the details of his budget but also must impart this information to his assistants so that the *team* can achieve its objective with *confidence* and *understanding.* The accounting department should set up a budget-accounting procedure which will provide an account for each budget allotment and then post expenditures under that allotment to that account (see Fig. 29.1). Such sheets as that illustrated should be checked constantly by a budget clerk in the accounting department, who should notify department heads when allotments seem to be in danger of being overdrawn in the future through any excess expenditure at the moment. Department heads should examine such sheets or summaries of them at frequent intervals, and check them against the departmental budget.

This checking is for the purpose of aiding in positive control. All too often budgetary operative controls are reduced to negative checks which tend to break down morale and bring the entire movement into disrepute. When properly operated, these controls provide a goal to reach and stimulate morale. One of the most effective means of getting all the supervisors behind a budget is to have some form of supervisory bonus to be paid for meeting or approaching the budgetary standard.[1] Action on new programs should not be taken by any department unless it is assured that the budget will not be endangered.

Of course, if a new program is necessitated by a situation arising after the construction of the budget, adjustments will have to be made to meet the requirements of the new situation. The budget must never become a restraint upon progress or scientific management but must remain a tool of efficient management.

Construction and other activities in which it is difficult to predetermine costs with accuracy must be checked more closely than normal manufacturing operations.

[1] See Chapter 25, p. 349, for a discussion of the supervisory bonus.

Operating the sales budget. Sales by salesmen, territories, and products are compared with estimated sales for the period, such as a month, and are summarized for the benefit of the major executives. The sample report given in Table 29.2 is illustrative of the type of information that should be provided for the sales manager and other major executives.

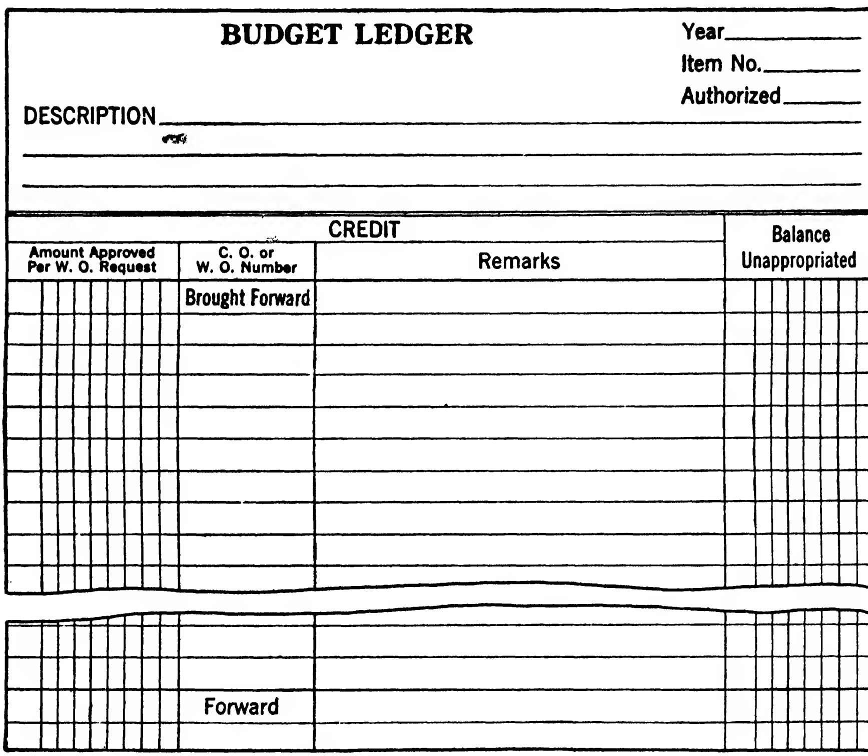


FIG. 29.1. Budget ledger form.

The sales manager is also interested in similar reports for the various regions and individual salesmen and in the sales by-products. If sales in a given territory are falling, the sales manager tries to determine the cause and may send special assistants to the region to aid. If the failure is caused by a drought or another natural reason, analysis may show that some other region is profiting through the misfortune of the drought area. Additional sales effort in the fortunate area may well absorb in part the unavoidable loss in the drought region.

Some budget officers, in addition to rendering special monthly reports similar to the one in Table 29.2, express the same data graphically.

Graphic representation is especially helpful in portraying trends (see Fig. 29.2).

TABLE 29.2

SALES DEPARTMENT BUDGET FOR OCTOBER (26 WORKING DAYS)

Income and Expense Accounts	Budget Estimate	Actual Figures	Variation	Percentage of Variation
Sales at list price	$ 200,000	$ 210,000	$ 10,000	+ 5.00
Total sales to date	2,400,000	2,640,000	240,000	+10.00
Salaries, executive and clerical	$ 4,200	$ 4,000	$− 200	− 4.76
Salaries, salesmen	4,000	4,000	0	0.00
Commissions	3,800	3,600	− 200	− 5.26
Travel	700	770	+ 70	+10.00
Advertising	6,250	6,250	0	0.00
Other expenses	800	750	− 50	− 6.25
Trade discounts	6,800	7,000	+ 200	+ 2.94
Department expense for month	$ 26,550	$ 26,370	$− 180	− 0.68
Nine preceding months	295,700	294,000	−1,700	− 0.58
Ten months to date	$ 322,250	$ 320,370	$−1,880	− 0.58

Controlling the labor budget. Labor budgeting is an essential element in the budgets of every department in a business. In order to predetermine costs over a period, it is necessary that some estimate of personnel costs be made. The payroll budget must show the number of dollars that will be applied in wage increases and in the savings incident to high-cost workers leaving and their places being filled with lower-paid newcomers. This is one of the most difficult items in budget preparation, and it is even harder to administer it within the limits that have been set down. Departmental executives must distribute the budgeted payroll in such a way that total labor costs for the department will be within budget estimates, and at the same time wages must be changed to conform to daily requirements. The departmental head must have his estimated payroll and his actual payroll constantly before him for comparison. Increases in salary must be given at the proper time to salaried employees. When employees resign and are replaced by others who do not receive the same rate, the budget is influenced. Incentive wage systems facilitate the predetermination of wage costs, and yet exact wages cannot accurately be predetermined. A variation of a few cents on the jobs of a number of workers for a number of days will make a great difference in labor costs over a budget period.

The personnel department must secure the labor budgets for the several operating departments, and make arrangements to have the necessary

number and type of personnel available at such times as the prospective manufacturing schedule indicates is necessary. Sufficient personnel must be hired to provide for the high mortality rate that occurs, even under the best conditions, immediately after hiring, and such personnel must be available in time to be trained when needed in the schedule.

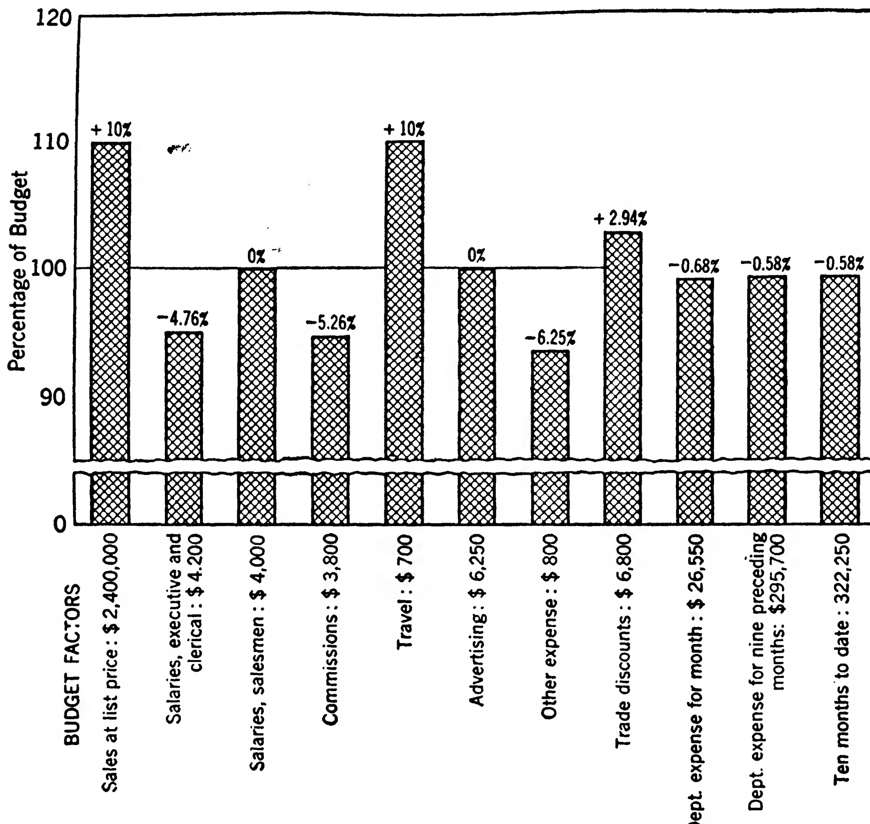


FIG. 29.2. Sales-department budget for October, 26 working days. Supporting data are in Table 29.2.

Operating the research and development budget. Few expenditures are more difficult to predict than allotments for research. The executive in charge of development and research is required in his original request to set forth in as much detail as possible what he hopes to accomplish, how long he estimates it will take him to achieve his goal, how much money he estimates will be required, and what results are expected if his endeavors prove successful. All expenditures on a given project are

charged against this particular undertaking. The executive in charge is notified monthly regarding the budget standing of his research. In turn, the director of research at stated intervals reports his progress to his superiors, including both the time element and the degree of success in his endeavors. When it becomes evident, as it often does, that the original allocation of funds will not be adequate to pursue the project to a successful conclusion, the director of research should notify the budget officer and his immediate superiors. He should report progress to date and file a new request for funds to complete the project if he thinks that such expenditures are justified. The budget committee and the management then have to decide whether finances permit further expenditure at the time, whether other researches should be deferred, or just what should be done with the available funds.

CHAPTER 30

MANAGERIAL CONTROL THROUGH COSTS

THE NATURE AND USE OF COSTS

The relationship of the cost-accounting department to other departments in the organization. Fundamentally the cost-accounting department belongs under the accounting or the comptroller's division, and there is a definite trend toward this organization. Probably the greatest deterrent to this trend is the lack of ability of many accountants to handle this work; they can carry out the computations, but they do not know enough about operations to set up and to maintain an adequate system for collecting the needed cost information.

In actual practice the cost-accounting department may be found under the industrial engineering or standards department, under the production-control division, under the plant superintendent, general manager, or some other important official. A consideration of the personalities involved or the capacities of the regular accounting division may be the determining factor in locating this important section of a business. At the time when cost accounting is established as a separate function, there may have been good reason for placing the cost work somewhere other than under the regular accounting division. Tradition and the momentum of an early start may preserve this separation long after the original cause has been removed. On the other hand, good cost accounting requires a thorough, although not necessarily a technical, knowledge of production processes, which often is lacking in the regular accounting section. This is frequently the determining factor in locating the cost-accounting department.

Cost accounting forms the soundest groundwork for information on which management decisions may be based and profits insured. Like other business methods, it is not an aim in itself. It is of value only in so far as it aids in operations and in making intelligent executive decisions that promote the healthy advancement of the business. Cost reports, regardless of their value, are inanimate and cannot themselves make improvements or insure intelligent operation. They must be studied by the executives and translated into the action toward which they point. They give the information for control, but they themselves cannot

do the controlling. Cost reports must be current if they are to provide a basis for managerial control. If the cost system is to serve such a function, it is essential that it be developed with a view to its utilization primarily as an instrument for managerial control. Since many students of industrial management have not had the advantage of a formal course in cost accounting, a few elementary concepts will be presented in this chapter.[1]

Classification of costs. Viewed solely from a managerial standpoint, the various classifications of costs are sometimes given as listed below. It should be remembered that this is not the usual accountant's classification.

1. Prime costs = direct labor costs + direct material costs.
2. Factory costs = prime costs + factory expense.
3. Production costs = factory costs + general expense.
4. Total cost = production costs + selling expense.

To make the series of equations complete it will be well to add another one:

5. Selling price = total cost ± profit or loss.

The accountant usually writes the cost equations as follows:

1. Prime costs = direct material costs + direct labor costs.
2. Factory costs = prime cost + factory expense.
3. Cost to make and sell = factory cost + selling expense.
4. Total cost = cost to make and sell + general administrative expense.
5. Selling price = total cost ± profit or loss.

Factory expense is composed of all those burden items which are capable of being allocated to the factory, such as waste, depreciation, repairs, taxes, insurance, indirect labor, power, heat, light, salaries of factory supervisors and clerical workers.

General expense includes general administration and managerial costs, such as main office salaries and expenses; legal costs; the portion of power, heat, light, depreciation expenses which is chargeable to the central office group; accounting; and other items, such as communication expense, general office supplies, and sometimes institutional advertising, public relations expenses, and similar items.

Selling expense includes those items that are directly chargeable to selling. The exact breakdown of this expense, like all the others, may

[1] It is highly recommended that all young men entering business study accounting, at least through introductory cost accounting. The fact that many of our successful managers today have not had such courses is no argument to the contrary. These successful men have acquired the fundamentals of accounting the long, hard way. Experience is a good teacher, but often an expensive one.

vary with the individual concern and the use made of the costs. Advertising, for instance, is frequently chargeable with little difficulty to sales, yet some institutions classify this item under general expense. (See Fig. 30.1.)

Elements of cost. Materials, labor, and expense are the simple elements from which costs are derived. Materials may be divided into two general classifications, direct and indirect. *Direct materials* are those that go into the product and can be directly traced to it. *Indirect materials* are those that are necessary in the production process but are not directly used in the product itself, such as coal, oil, and sandpaper. Certain other materials that go into the products but are difficult to trace to a given product are often classed as indirect material, such as nails, glue, putty, and sometimes paint. The same material may be a direct material for one producer and an indirect material for another.

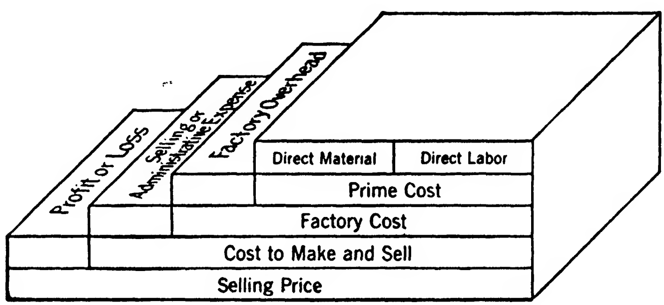


FIG. 30.1. The cost steps.

Labor is also classified into two groups, direct or productive and indirect or nonproductive labor.[2] *Direct labor* is capable of being allocated to a specific product or products, whereas *indirect labor* cannot readily be thus assigned. The method of wage payment may influence the classification of labor as direct or indirect. A janitor is ordinarily paid on a day-rate basis, and his work is usually classified as indirect. In some departments the entire group, including the janitor, may be paid on a group piece-rate basis. In this case the janitor service is directly allocable to the product and therefore is classified as direct labor.

Another group of items entering into costs is known as *overhead expense* or *burden.* Depreciation, interest, rent, taxes, heat, light, and

[2] "Productive" and "nonproductive" in a sense are inaccurate when applied to labor, although they are in common use. All labor should be productive or else abolished. The mere fact that labor may not be directly traceable to a given product does not mean it is nonproductive in the strict sense of the term.

power, and similar items are just as much a matter of cost as materials and labor. Expenses may also be divided into two classes, fixed or constant and variable or fluctuating. *Fixed expenses* are those costs that tend to remain relatively constant regardless of the volume of production, such as the interest on bonds, taxes on land, buildings, and equipment, depreciation arising from the passage of time, and rent. *Variable expenses* are those items that tend to vary with the volume of production, such as depreciation arising from use, royalties paid on a volume basis, power, salaries of minor clerks and some subforemen.

Interest, taxes, rent. In a strict economic sense there may legitimately be some argument about classifying rent, taxes, and interest as expense items. From the managerial point of view these expenditures are a charge against the business enterprise and as such must be paid out of revenue or out of capital if the revenue is not large enough to cover all outlays. Regarded in this light, they are in a very real sense expenses.

Distribution of factory expense. Products resulting from the manufacturing process may for convenience be classified into the following four groups:

1. The primary product.
2. The by-products.
3. The joint products.
4. Waste.

The *primary product* is the simplest classification and may be readily recognized as the main product which the enterprise is designed to produce, such as steel in the steel mill and fabric in the textile mill. A *by-product* is a product resulting from the manufacture of a primary product. It may have considerable value, but its production is purely incidental to that of the major product. Cotton seed is a by-product of the "ginning" of cotton. In the past, by-products have often been ignored. Even today items that might well be marketed as by-products are often ignored unless the total volume is large. For instance, small packinghouses frequently do not have the full line of by-products that large packers have. When each of two products resulting from the same production process has considerable value, they are known as *joint products*. Illustrations are common, such as butter and buttermilk, meat and hides, coke and artificial gas. The relative values of two joint products are usually more nearly the same than those of a by-product and its primary or major product. *Waste* may arise from the manufacture of a major product, joint products, or a by-product. Waste has relatively little value and sometimes may constitute an expense, in that money must be spent to get rid of it.

From a cost standpoint a primary product carries all costs that can be allocated to it. All costs incurred in processing the by-product after it is separated from the major product are naturally chargeable to the by-product. If the competitive market for the major product is keen, the sales price of the by-product minus all costs allocable to it is frequently subtracted in figuring the cost of the major product. In an effort to find true costs this practice may be followed anyway, but it is almost certain to be done where margins are low and competition is keen. In the manufacture of joint products all costs incurred after the two products are separated are usually allocated to the respective products. The costs of the joint products up to the point of separation are often divided between the two on the basis of the total sales value of each. The cost of saving the waste is naturally charged to the waste. The recovery value is usually so low that no special effort is made to figure it into the cost of the product from which it is derived.

The distribution of factory expense is complicated even for a major product and becomes increasingly so for by-products and joint products. Absolute accuracy is not possible, but accuracy for managerial control is attainable. To illustrate some of the methods used and some of the difficulties involved, a few of the bases for distributing factory expense are presented.

Direct labor as a basis of distributing expense. Direct labor as a basis for distributing factory burden is approached from two angles: namely, direct labor hours and cost of direct labor. These two approaches would give the same result in a situation in which the men were paid at the same rate on a time basis. Such a condition seldom prevails; hence the two systems are usually different. The distribution of expense on the basis of direct man hours worked on a given product is predicated on the assumption that these expenses are proportional to the man hours worked. The system is simple, and it is probable that its simplicity may account for its wide use. When the rates paid the workers are relatively the same and the amount and the nature of the work vary only slightly, this system is accurate for most purposes. It has the advantage of emphasizing the time element in the distribution of indirect costs; however, it emphasizes only "worked" time and does not consider "elapsed" time, which is also an important item in costs. This system does not distinguish between the different kinds of equipment that may be used in processing work possessing different characteristics. It is self-evident that a carpenter working with hand tools is not in fact carrying as much burden as a man working on a large boring mill in the same department.

Distribution of burden on the basis of the cost of direct labor is a modification of the direct labor-hour basis. Where the rates vary ma-

terially in the department, the results of the two systems will be different. The direct labor-cost basis of distributing expense is predicated on the assumption that burden is proportional to the direct labor cost. This system ignores the effect of elapsed time and does not emphasize the time worked quite so definitely as the direct labor-hour basis. The other advantages and disadvantages of the direct labor-cost basis are essentially the same as those of the direct labor-hour basis, but the direct labor-cost basis has an additional advantage in that the data are accumulated for other purposes and need not be specially segregated in the same sense that labor hours have to be collected.

Direct material as a basis of distributing burden. The distribution of expense on the basis of direct material is predicated on the theory that indirect costs vary in direct proportion to the direct material used. This system is logical for continuous-process manufacture of a standardized product. If more than one line is turning out products that are materially different or if the same line turns out different products, this system tends to be less applicable. It is of doubtful value for burden distribution for an industry producing a variety of products.

Prime cost as a basis of distributing burden. Prime costs are equal to the sum of direct labor costs plus direct material costs. Burden distribution on the basis of prime costs is in reality a combination of the systems which have been described and possesses both the advantages and the disadvantages of each. This system has not met with widespread acceptance.

The machine-hour rate as a basis of distributing burden. This method has been in use in a general way for a long time.[3] The machine rate basis of expense distribution in its more highly developed form strives to allocate to each machine its true expense when considering all costs, such as original cost of machine and expected life, power consumption, heat, light, floor space occupied, maintenance. By carefully estimating the expected use of a machine and dividing all costs allocable to this machine for a given period by the total number of expected use hours, the burden charge per hour can readily be obtained. By keeping a record of the time a machine is used in manufacturing a given product, the burden cost of each machine can be charged to the product. This method involves considerable record keeping, but it is theoretically preferable to many of the other systems. Failure to use the machine the anticipated number of hours leaves a portion of the burden undistributed, whereas usage of the machine for longer than the estimated time distributes burden greater

[3] See Dexter S. Kimball, *Principles of Industrial Organization,* McGraw-Hill Book Company, New York, 1939, p. 317.

than is factually justified. Again, if a machine larger than necessary is used for a given job because machines of the proper size are overloaded or broken down, the particular product thus processed will be charged more than it should ordinarily be. It is true that these shortages or excess charges may be accumulated over a period and adjustments made, but it is not so easy to make these adjustments for an individual product in a jobbing shop. Individual costs including either excesses or shortages in burden distribution are particularly undesirable when they are used later for estimating purposes.

The production center as a basis of distributing burden. The production-center method of expense distribution is a logical expansion of the distribution by machine-hour method and eliminates most of the objections of the machine method. A given production center may or may not be separated by aisles or partitions. Each center does, however, have definite boundaries and may well be thought of as a special room. All the charges for this particular center, such as floor space, repairs, heat, light, power, and maintenance, can be allocated to the center as a unit. These total charges are then distributed on a time basis over the total product moving through the center. This system is theoretically sound, but it requires a great deal of careful work to establish correct rates for each center. The same problem of overcharges and undercharges arises as in the machine rate basis in cases where the center has less or more production than was anticipated for the given period. Excess charges because of using a larger machine than necessary are less likely to occur under the production-center method of expense distribution than under the machine basis because the production center usually has both machines.

Combining various methods in distributing burden.[4] The cost-accounting system should be adjusted to the needs of the situation. Two or more systems may logically be used within an organization when they best serve the requirements of the enterprise. In one department practically all the production may be machine work, and the basis of burden distribution may well be the machine-hour method or the production-center method. In another department of the same enterprise most of the work may be hand assembly either on benches or on assembly line. In this department the direct man-hour or direct labor-cost basis may well be the best one to use. In a department where there is a large amount of both machine work and hand work it may be advisable to apply machine burden such as power, depreciation of machinery and equipment, repairs

[4] See Charles F. Schlatter, *Elementary Cost Accounting,* John Wiley and Sons, New York, 1927, pp. 269–271.

and maintenance of machines, and insurance and taxes on the machines, by the machine-hour method; and at the same time distribute burden arising from supervision, welfare expense, heat, light, and other items that apply more intimately to the workers than to machines, on the direct labor-cost basis.

Using cost information. There are at least two important uses of cost information, namely, for control of operation and as an aid in price determination. In the short run competition may be the determining factor in price. Even in the long run competition may set the upper limit of price, but the long-run lower limit of price under competitive conditions tends to be determined by the cost of production of the representative firm in placing the goods on the market.[5] In other words, costs determine the survival of a company rather than the price of its goods, since price is determined by competition in a free market. Current costs influence price largely through serving as a signal to indicate whether operations are profitable at a given price. For a time it may be better business to continue to sell at a price which does not recover all burden costs rather than not to sell at all.

From the standpoint of the industrial manager costs serve as a chart for control. When standards have been accurately established, failure to meet these standards is a signal for managerial action. To be effective in control, costs must be allocated in such a manner as to coincide with areas of responsibility. It is a waste of time for control purposes to send a foreman a report showing an increase in the cost of production arising from conditions over which he has no control. The responsible executive should be charged only with those costs over which he exercises reasonable control. The foregoing statement raises the question of the disposition of the excess unit burden costs arising from a decrease in the volume of production. It is self-evident that the enterprise as a whole must bear all costs whether or not they are currently recovered in the selling price of the product; however, it does not follow that each individual department must be charged for control purposes with all costs. If the department is not charged with all the expense, how should the undistributed burden be handled? One method is to establish a burden charge for each department for an expected normal volume and to use this charge as a basis even though production may fall below this norm.[6] The excess burden would then be applied directly to profit and loss as a charge against management rather than against the individual department. This

[5] See Paul F. Gemmill, *Fundamentals of Economics,* Harper and Brothers, New York, 1935, pp. 440–459.

[6] In substance this was the method advocated by H. L. Gantt in his article in the *Journal of the American Society of Mechanical Engineers,* August, 1915.

or a similar program is incorporated in standard costs, which will be discussed later in this chapter.

DEPRECIATION

Depreciation defined. *Depreciation* is defined as *the reduction in the value, or the effective economic life, of a product arising from the passage of time, use or abuse, wear and tear, influence of the elements, or the cessation of demand for use.*[7] As this definition implies, depreciation frequently is used to include obsolescence and inadequacy or supercession.

The mere passage of time creates physical decay or decrepitude in such things as buildings, boilers, rubber products, and other productive instruments. Repairs will prolong the life of such items, but eventually they must be replaced. Wear and tear take place with use and are relatively proportional to use; however, the time element may influence the rapidity of wear. When a factor of production is being consumed in production, regardless of the cause, provision should be made to accumulate funds out of the selling price of the product to replace the item when no longer usable.

Fixed assets are constantly being converted into expense which must in the long run be recovered in selling price in order that the buildings and equipment may be repaired during their effective lives and replaced when they are no longer economically usable.[8] This expense arising from the conversion of fixed assets into the product sold may take several forms, such as wear and tear and physical decay resulting from the passage of time, obsolescence, and inadequacy. Inadequacy in and of itself may not in a strict sense be an expense, but it certainly lessens the value of the item to a going concern and thus gives rise to excess expense if the equipment is forced to do work for which it is not large or powerful enough. Again, inadequacy may compel the purchase of additional equipment, an expenditure which would not be necessary if the equipment were adequate.

Obsolescence. *Obsolescence* is a term used to describe the process of equipment's becoming out of date. The equipment may still have useful productive life for the specific operation for which it was originally purchased, but this operation may no longer be economical because of the development of newer types of equipment, new processes, or new inventions. Obsolescence differs from *inadequacy* in that obsolete equipment has little or no value save for scrap, whereas inadequate equipment may

[7] See L. P. Alford, *Cost and Production Handbook,* Ronald Press Company, New York, 1937, pp. 1215–1221.

[8] Land is an exception to this statement.

have much valuable productive life remaining. Equipment inadequate in one situation may be entirely satisfactory in another where there is less work to be done. Obsolescence is more common in newer industries in which development of processes and product is more rapid. A basic discovery in any industry, however, may render much of the equipment obsolete. Model changes in the product may render certain tools and dies for the old model obsolete, not because they are replaced by a newer tool for the old product, but because the product has changed, so that new tools and dies are required. This situation is common in the automobile-body industry. Systematic provision for the obsolescence of equipment is difficult, save in those industries in which models change at regular intervals; the special equipment is then frequently written off in a short time. It is not uncommon to find that no attempt is made to segregate obsolescence as such; it is included in depreciation by making provision to retire the equipment in a shorter period than would be justified by wear and tear arising from use or the passage of time.

Depletion. Certain business assets, such as coal or iron deposits, timber, and clay deposits, are consumed in being prepared for market. Minerals, when removed from the earth, are not replaceable. Provision may be made to replace trees, but such replacement takes a long time. Earnings from operations such as mining represent two items: (1) profits from operations, and (2) recovery of part of the capital investment. Reduction of the mineral deposit through removal for use is known as depletion. It may be legitimate to distribute to the owners the total income from such operations, but they should be clearly earmarked to avoid confusing a return of capital with earned income. Patent [9] rights and franchise privileges lose their value with the passage of time, and provision should be made to amortize their value during their effective lives; there will be a partial depletion of capital if the total income is distributed. Provision for depletion may be made through investing the accumulated funds in similar or other assets; instead a special sinking fund may be established by investing these funds in income-bearing securities and reinvesting the income, so that the total amount will be available at the expiration of the effective life of the item.

Basis of depreciation. Before discussing the simple methods of depreciation, it is well to consider the three common bases of depreciation: (1) original cost, (2) replacement cost, and (3) present value or appraised cost. There are some advocates of a fourth basis: original cost plus

[9] A patent grants its owner the exclusive right to manufacture for seventeen years; a copyright is effective for twenty-eight years and may be renewed for another twenty-eight.

maintenance cost.[10] This fourth basis is of doubtful value, however, and has not found wide acceptance. Depreciation on the basis of original cost, which includes transportation and installation costs, is simple and easily determined by referring to the equipment ledger. Depreciation on this basis will tend to retain the original investment intact. Some authorities argue that the objective should not be merely to preserve the original investment but to preserve the organization as a going concern, and that this purpose will not be accomplished by merely recovering original costs during a period of rising prices; hence they advocate depreciating the asset on the basis of its replacement cost. There is considerable merit to their argument, but its practical application involves a great deal of accounting and revision of depreciation charges as price levels fluctuate. This basis has merit when appraising an enterprise for financing and insurance purposes, but it has little standing with the income-tax collector and may be criticized on the basis that costs as far as possible should reflect actual, rather than estimated, expenditures.

The present-value basis or the fair market-value basis has had particular standing in certain special cases involving property acquired before March 1, 1913, and property acquired by gift or transfer in trust after December 31, 1930.[11] In industry in general, however, it has relatively little significance.

Methods used in computing depreciation. There are several methods of figuring depreciation; however, the *straight-line*, the *sinking-fund*, the *percentage-on-diminishing-value*, and the *machine-hour methods* are the most common ones.

1. The *straight-line* method of depreciation assumes that the depreciation takes place in equal increments throughout the life of the equipment. The life expectancy of the machine is estimated, together with its scrap value. From the cost of the machine is subtracted the scrap value, and the remainder is distributed equally among the estimated years of life of the machine. For instance, a machine costing \$1400 and having an estimated life of 10 years and scrap value at the end of this period of \$200 would have an annual depreciation of \$120, computed as follows: $(\$1400 - \$200)/10 = \$120$. This method gives a constant-depreciation rate for each year which in reality does not conform to actual depreciation, since a machine depreciates more during the first few years of its life than during the last years. Maintenance costs are greater during the later years of the life of a machine, and these, when added to the straight-line depreciation charge, will give an unequal

[10] See L. P. Alford, *op. cit.*, p. 1232.
[11] *Ibid.*, p. 1235.

charge against production. If it is desirable to have a relatively constant machine cost chargeable to production, the straight-line method is not satisfactory. It is, however, in wide use, probably on account of its simplicity and ease of computation.

2. The *sinking-fund* method of depreciation applies the sinking-fund principle to accumulating depreciation charges. The amount to be depreciated is found by the same way as in the straight-line method. By an algebraic formula the amount of money that must be set aside periodically in equal amounts and to which interest at a given rate is credited is determined so that the accumulated total will equal the amount desired to be available at the end of the period. The formula may be written as follows: $A = V\ (r - 1)/(r^n - 1)$, in which A represents the annual depreciation charge, V equals the total fund to be accumulated, n represents the life of the equipment, and r equals the rate of interest plus unity, or 1. This formula may also be written $A = Vr/[(1 + r)^n - 1]$. A simpler method is to use compound interest tables to find the amount which $1 per annum compounded at r interest rate will equal in n years and then divide the total amount to be accumulated by the amount that $1 will accumulate for the period. The quotient will be the amount to be set aside annually. To illustrate, using the same problem given under the straight-line method: $1200 is to be accumulated at the end of 10 years at 5 per cent. One dollar deposited or set aside annually at 5 per cent compounded interest will accumulate $12.578 in 10 years. To accumulate $1200 in 10 years on this basis, $1200/$12.578 or $94.586 will have to be set aside annually. The sinking-fund method is merely used to calculate the depreciation; it is very seldom indeed that an actual sinking fund is provided for this purpose. A reserve for depreciation is usually set up regardless of the method of figuring the depreciation. The sinking-fund method is interesting in that it indicates the nature of the depreciation problem from another angle, but it has found little acceptance in industry.

3. The *percentage-on-diminishing-value* method reduces the annual depreciation charge in that each year's depreciation is subtracted from the preceding year's value of the equipment to establish the new reduced base for the ensuing year. If s = the salvage value of the equipment at the end of n years and C = the original total cost of the machine, then the annual rate r to be applied to the diminishing value is found as follows: $r = 1 - \sqrt[n]{s/C}$. This system places a heavy charge on the earlier years of the life of the machine, as, of course, it is designed to do. It leaves an insignificant charge for the later years of the life of the equipment.

4. The *machine-hour* method of figuring depreciation is founded on the theory that depreciation is proportional to use. The estimated number of hours the machine may be used before replacement is taken as the base, and this figure is divided into the amount to be depreciated to get the machine-hour rate of depreciation. This amount is then charged as a depreciation expense for each hour's use of the machine. The system has much to commend it but has not received wide acceptance in practice. As a matter of fact, the *straight-line* method of depreciation is the one in most common use.

Using Cost Data

Use of cost information. If new functional departments are constructed or if development programs are undertaken, the cost system must allow computation of the savings effected through the changes. Otherwise these new departments or new work may have difficulty in establishing and holding the esteem of other branches of the business, particularly any that opposed the change before its introduction. Thus, if job-study work is developed, it is most desirable to be able to balance the cost of taking the studies against the savings achieved through lower unit costs on the operations studied. If a planning department is instituted, it should be possible to know the savings in direct and indirect labor in the factory departments which have resulted from the expenditures incident to the creation of the planning force. Such information becomes of particular value when extension of planning work is contemplated, since it answers opposition successfully when the planning department has proved its value, but it prevents hasty extension when conditions demand a higher degree of success with work already undertaken, rather than the assumption of new work.

The cost-accounting department should be in a position to furnish valuable statistical information, or, if there is a separate statistical department, to give this department the basic data from which the statistical information may be gathered. The personnel department should be able to gain accurate information concerning the actual cost of replacement of workers. Such information can be secured most logically from the cost records. Although the data may be taken off the production records by the planning department before they are turned over to the cost department for costing, nevertheless this is primarily a cost problem. Such studies are only samples of the way in which cost information may be utilized.

In periods of depression when the payroll must be cut at all hazards and regardless of ultimate cost, departmental analysis of costs which indicate savings effected under different operating conditions, as well as actual expenditures, makes possible intelligent pruning of the payroll,

rather than using the hit-or-miss methods which are inevitable if analyzed data are not available.

Standard costs. In standard-cost systems the normal expenditure for material, direct labor, and overhead charges for a given product or for a number of hours' production in a given department is computed. This allows the elimination of much detailed cost analysis and at the same time permits adjustment at the end of a period through the totaling of actual departmental cost during the period and comparison with the normal or standard cost. If the actual cost of a given job performed during the period is wanted, the figure may be secured through applying the ratio for the period between the normal and the actual cost of all jobs to the particular job in question. Such a system is valuable because it permits the formulation of long-run production and sales policies which are not disturbed by minor fluctuations in operating conditions, and furthermore it makes possible the separation of normal production costs from costs which are due to the position in the business cycle or to general efficiency or inefficiency in the management as a whole.

If an attempt is made to secure an absolutely accurate cost on each order, a cost that will currently absorb all overhead or indirect charges, a fluctuating cost necessarily results, making difficult the determination of long-run business policies. With a plan of standard costs, prices remain fairly constant, and losses or gains in operation are directly chargeable to the general business accounts which are responsible for them rather than to the departmental or other accounts which have had no responsibility whatever for the conditions as they exist. Thus volume of business comes to be figured in terms of hours of production and quantity of product, rather than in terms of dollars of business. This is a far more accurate estimate, because the basis of dollars of business is always likely to include a more or less constant fixed overhead burden.

Under many cost systems in which overhead costs are largely prorated as business is carried on, these costs have not been added in sufficient quantity when business was good, thus cutting down selling prices and prohibiting the establishment of a reserve for bad times. Similarly, they have been added too heavily in times of slight production, with the result that costs have increased as selling has become more difficult. Frequently, managers have realized the impracticability of spreading overhead over a greatly diminished product and have charged a large share of it directly to the profit-and-loss account. They have less commonly kept their overhead up during times of prosperity, so as to create for themselves a reserve to which they might charge the unabsorbed overhead in times of depression.

Idleness expense. The reports on costs of idleness give the general management much information with which to direct its general policies. If the plant is operating on a part-time schedule only, the cost of maintaining the idle portion of the plant must be either absorbed in the selling price of such articles as are manufactured or charged directly to profits. Of course, overhead expenditures must be taken care of; but, if they are absorbed in the product being manufactured, the causes of idleness and of the increased unit overhead charges are not likely to be brought to the attention of those in a position to correct them. If these charges are directly listed under some such heading as idleness expense, they will force themselves to the attention of the chief executives for correction, and selling prices can be fixed to include some of this cost of idleness or to exclude it entirely, as may be deemed wise under the prevailing conditions. This policy will be determined largely by considering whether the product can be sold in competition if the expense is added.

The planning department not only is able to furnish the cost department with information concerning idle equipment but also is in a position accurately to determine the cause of the idleness. It remains for the cost department merely to compute the cost of idleness and to submit reports to the executives responsible. These executives may then take the necessary remedial action in an attempt to reduce or eliminate the existing idleness. Of course, the necessary information concerning causes of idleness can be secured without reference to the cost department, but the inclusion of cost figures not only gives the information attention value but also permits comparison with the cost of taking steps to remedy the conditions causing the idleness.

Fixed and variable costs. Variable costs, which change almost in proportion to the amount of business done, include direct wages, direct labor, and certain types of indirect expenses, such as the salaries of minor executives, who are easily dropped in times of poor business, and income taxes, which vary almost directly with business done. Fixed costs remain constant, almost irrespective of the amount of business done. These costs include not only the salaries of major executives, but also interest on investment, particularly borrowed money, taxes on property, and certain obsolescence charges on both materials and equipment. Cost reports should clearly differentiate between these fixed and variable costs. Although the rendering of idleness-expense reports will partially cover this field, nevertheless both the cost department and the interested executives should bear in mind constantly this distinction between variable and fixed costs. Any reports that clearly separate them will be of major assistance in the formulation of sales and production policies and of administrative budgets.

During the determination of major policies fixed costs must first be covered by receipts from sales in income computation. Thus, if fixed costs are $2000 per week and sales are $5000 per week, a balance of $3000 is left for the payment of variable costs and profits. Although variable costs vary with the volume of goods sold, for any given unit of goods they remain practically constant; that is, for 50 units they will be practically double the amount for 25 units. Variable costs differ proportionately with the amount of goods produced. The approximate variable cost per unit may be readily determined. If we assume that the $5000 of sales represents 50 units of product, the variable cost of which is $60 per unit, a variable cost of $3000 to be applied to the week's sales is obtained. Inasmuch as this is the exact amount remaining after deducting fixed costs from sales, it follows that the week's business was done practically at cost. If $7500 of business was done, $5500 would remain to be applied to variable costs, which at $60 per unit would be only $4500, with $1000 remaining for profit. If $4000 of business was done, there would remain but $2000 to be applied to variable costs, which would be $2400; there would be a loss of $400 on the week's business.

In most businesses the computations are not quite so simple as those in the illustrations, inasmuch as fixed costs do not remain exactly fixed, and variable costs may not remain the same per unit of product. As production increases, the variable cost per unit is likely to decrease somewhat. Possibly some other variable costs also decrease slightly. In some cases these variable costs of different types will have to be segregated in the cost reports. Tables can be prepared which will indicate the variable cost per unit at different points in the production scale, as well as modifications in fixed cost which are likely to occur as production changes. With these data the general management will be in an excellent position to determine general sales and production policies, although the information thus obtained will not be exact enough for the accurate fixing of selling prices. Thus a consideration of fixed and variable cost is useful mainly as a guidepost for the formulation of major business policies.

Budgeting and the cost system. In making the budget, the cost records of past years give dependable information, but the current cost figures must be utilized in laying out the program for the months to come. During a budget period cost records can be carefully analyzed only in the light of the budget, which was prepared as a goal. The cost record becomes the progress report on obligations fulfilled by department heads and permits modification of operating procedures or change of business plans during the course of a budget period. This fact indicates the necessity for developing cost records in accordance with the organization of the business.

Standard costs are a valuable aid in budgeting, although it is possible to use the budget without standard costs.[12] Although no particular phase of sound management will alone insure successful operation, all operating decisions must in the end be based on costs. Thus cost becomes the basis on which the expediency of management policies and decisions is determined. Costs must be accumulated not only accurately but also in a manner which permits their utilization for the formulation of management policies and the execution of management programs.

[12] See Paul E. Holden, Lormsbury S. Fish, and Hubert L. Smith, *Top-Management Organization and Control,* Stanford University Press, Stanford University, 1941, pp. 152–161.

CHAPTER 31

CLASSIFICATION AND IDENTIFICATION

Classification defined. A classification is a detailed, systematically arranged list of all items pertaining to a particular phase of a business or to all the various phases of a business. Classification, under modern business conditions, is a necessity, and the merits and results of classification should not be confused with the advantages of the various systems of symbolization which make the classification usable in the day-by-day operations of the business.

It will be recalled that classification is one of the basic steps in scientific methodology. These steps may be restated as follows:

1. Observe accurately all the facts involved.
2. Classify and combine all the facts on the basis of some common relationship or relationships.
3. Interpret the relationships in terms of a law or statement explaining the observed relationships.
4. Test the formulated statement or law and note any deviations.

The use of classification. Classification *facilitates interpretation* and *ease of reference* of seemingly unrelated facts. Not only are known data rendered usable by classification, but also unknown relationships have been hypothecated in terms of logical interpolation of the known ones. Satisfactory wage rates for new operations have frequently been established by reference to classifications of similar work. New jobs have been evaluated in terms of established classifications.

When the number and variety of records that are necessary in the modern organization are considered, it becomes apparent that a definite classification of the data pertaining to the various activities is necessary. Otherwise, there are likely to be duplication and overlapping in the collection of such data. Classification within a business makes possible the establishment of a system that makes record collection routine.

The advantages of classification development are as follows:

1. It clearly indicates the plan of organization, in that it shows the relationship of divisions and departments and interprets the limitations of their activities.
2. It establishes a method for obtaining the information necessary for the operation and control of an effective accounting system, facilitates the collection of data pertaining to indirect expenses and manufacturing costs, and aids the establishment

of monthly inventory balances of stores, materials in process, worked-material stores, and finished products.

3. It aids in standardizing the arrangement of articles in storerooms and prevents the incorrect issuing of articles, such as often happens when names or shop terms are used on the requisition.

4. It furnishes a means for routing and controlling material in process by accurately designating the materials, machines, work places, and operations entering into each process or component part.

5. It makes possible the collection of detailed information relative to buildings and equipment.

6. It provides a logical system for the filing of all data.

7. It aids materially in showing tendencies; thus a comparison of performance over a period of time for any operation or activity shows the direction in which this item is moving. A comparison of classified expense items invites managerial approval or action.

8. It aids the development of standardization. The word is here used in the special sense of the determination of the best method or the best material to use for any given purpose under existing conditions, and strict adherence to the best as a standard until a better standard is found. In almost every instance in which classification is applied, it will be found that a large number of almost similar articles are being used for similar purposes. In order to reduce the amount of classification work, if for no other reason, there will be a tendency to reduce the number of items. This reduction helps to create standards. When a particular item is ascertained to be the best, it is adopted, classified, and recorded.

The basis of classification. The first consideration in the determination of the basis of classification is the expected use to be made of the classification. A second consideration, unless it is definitely predetermined that the classification is for temporary use only, is a provision for expansion. Often a different basis will be used for a classification for a specific purpose of temporary duration than for a permanent classification. A few of the bases for classifying raw material are illustrative of the range that is possible.

1. Classification by the *nature of the materials* themselves, such as liquids, solids, gases; acids, bases, salts; metals, woods, ceramics.

2. Classification by the *use to which they are put* or the *purpose served,* such as direct materials and indirect materials, mechanical rubber goods and automobile tires, tubes, and flaps.

3. Classification according to the *location of the plant* or *department where the material is used.* This method may be in use if two or more plants in the same area are under the same general management but are operated as separate units.

Classification by the nature of the material is by far more universal and is capable of indefinite expansion into a logical system. Such a system may be complicated for a relatively small plant, but in large, complex institutions it is often a necessity. Classification on the basis of the use to which materials may be put is simpler for smaller organiza-

tions, and to the mind of the average workman untrained in the techniques of classification this system has a strong appeal. It seems logical to him to associate the material with its use. As far as the worker is concerned, classification by location is similar in many ways to classification by use.

For cost purposes it is highly desirable to apply labor cost to the product on which the labor is expended. From a control angle, labor may be classified as *direct* or *indirect*. In terms of the employment office, labor may be grouped as *unskilled, semi-skilled,* or *skilled*. On the basis of job classification for wage payment the items of skill, length of training required, hazards, unsatisfactory working conditions, such as the presence of heat, dust, or water, and wage customs may all be combined to establish a graph on which the various occupations are placed. Regardless of the given base used for classifying any material, product, service, or persons, attention should be devoted to whether the basis selected is *adequate* and whether it is *capable of expansion to meet changing conditions*.

Developing a classification. The first step in the development of a classification is to list every element of the business with infinite detail, taking into consideration all existing departments, all materials in stores and in process, all finished products, all work places and machines, all operations performed, all fixtures and tools, all buildings, and all possible sources of expense. After the preliminary data have been gathered, the subjects to be classified are divided and grouped into a number of main classes, each of which is designated by either a number or a letter, depending on the method used. Each main group is then subdivided or further described to the extent that is necessary. After each group and subgroup has been formed and carefully revised, the attaching of symbols to each item may be begun.

Simplicity is the keynote of good management. Care should be taken not to subdivide the main groups any more than is actually necessary; otherwise the symbols will be long and possibly unwieldy. On the other hand, simplification of the classification should not be carried to such an extent that confusion or misunderstanding will result.

Care should be taken to classify and symbolize no more features of the business than will actually be utilized daily when the standard nomenclature has been built up. The cost of classification is heavy, although the return on the investment is large. Certain fundamental features can be used in almost every classification, but there are others in which nicety of judgment must be exercised before deciding whether to incorporate them. For instance, almost every plant has need for some control over its raw materials or parts in process in the storeroom. To secure

this control it is necessary to establish a method of requisition withdrawal from the storeroom. As soon as this method is introduced, standard nomenclature generally becomes a very useful mechanism, both for the location of the article itself in the storeroom and for the abbreviation and simplification of the clerical work attached to the writing of requisitions.

An example of when not to use too much classification can be found in almost any of the continuous or analytical industries which handle a single material from start to finish. In such an enterprise an elaborate classification for routing, including identification of all materials in process, finished product, machines, and work places, might be expensive, burdensome, and unworkable. On the other hand, an involved assembly industry is lost without a good routing classification. The classification of duties and functions of individuals has not been carried so far as the classification of the other aspects of industry. In recent years, however, considerable attention has been given to job classification[1] and some attention to the personnel audit, which is based upon careful classification of all jobs or occupations.

In establishing a classification system many unforeseen "kinks" will probably develop, and provision should be made for quickly investigating and correcting any difficulty. A classification is useful only to the extent to which it is kept up to date. An accurate record of all persons holding copies of the classification should be kept, so that, when changes are made in the original classification, arrangements can be made to have additions and changes entered on all copies. This problem can best be handled by the methods or research department, if one exists; in some institutions the production-control division has charge of this function.

Identification. It is impossible to have a workable classification without a system of identification. The simplest form of identification, which is the use of the regular name for the article or service identified, may be satisfactory in a small institution having only a few items; however it is extremely burdensome, wasteful, and subject to error when applied on a large scale. Identification is accomplished also by the use of signs or symbols, numbers, letters, or a combination of these with words. In actual usage these name substitutes become quite as well known as the name itself. Probably the best-known use of symbols, familiar to high-school students, is the chemical formula.

Plants, buildings, production centers, machines, trucks, products, many parts, forms, and various accounts are often assigned an identification

[1] See American Management Association, *Personnel Series, No. 39,* pp. 17–22; also Industrial Management Society, *Occupational Rating Plan for Hourly and Salaried Occupations,* 1937.

other than their common names. Such a procedure promotes *precision* and *accuracy* and materially reduces the chance for error when once the identification symbols or numbers have been firmly established. The use of appropriate identification numbers greatly reduces the amount of clerical writing necessary in connection with records of parts, materials, and operations. It is customary in production control to refer to the operations in sequence, as well as to the machines upon which the various operations are performed, by appropriate identification numbers. The use of numbers to identify labor operations and materials facilitates machine tabulation of cost data. An adequate system of classification and identification is both a convenience and a necessity in large-scale mass production.

Broadening the use of the system ot identification. In some companies one system is used by the sales department, another by the product-design or the engineering department for blueprints, a third by the production-control and the manufacturing division, and still a fourth by the accounting department. Needless to say, such a program entails a great amount of editing when orders are received and costs are accumulated. At times there may be good reason to use one set of identifications for sales when these numbers have become well established in the trade. Nevertheless the ideal would be to have the same identification system used throughout the company. This is possible if the respective heads of all interested departments collaborate in setting up the system. Tabulating equipment is becoming increasingly popular in collecting cost data and production control. Such equipment requires that numbers be used for identification. On installing such a system, it is highly desirable to standardize the system of identification throughout the company if possible.

Systems of identification. The various systems of identification that have been widely used are as follows:

1. *Alphabetical:* the use of a letter or a group of letters according to some predetermined scheme.
2. *Mnemonic:* the use of letters in some such combination that they suggest the classification name of the particular item. Numbers may be combined with letters in the mnemonic system, particularly to suggest size or some generally accepted standard.
3. *Numerical:* the use of numbers to identify the particular item.
4. *Sign:* the use of symbols or signs to indicate items or operations. These have been extensively used in motion-study techniques.
5. *Combination:* the use of any of the foregoing systems in combination with any other one or all others to identify a particular item, service, or operation.

Frederick W. Taylor and his associates contributed the mnemonic system of identification to scientific management. The most valuable aspect

of this system is that it may be expanded to classify and symbolize every single phase and item of a business in a way that makes the nomenclature a unified whole without repetition of symbols. Another great advantage is that the mnemonic system, as its name suggests, aids the memory by suggesting the classification name. To illustrate, ML signifies *mill;* GR, *grind;* AM, *material accounts;* and DP, *punch-press department.* This system is of such general application that it is discussed in detail in Appendix B.

Letters have been used extensively to identify buildings and departments. It is but a simple step to progress from single letters to combinations. Many of these were worked out before the introduction of the logical mnemonic system. For instance, Department A in Building B may be known as BA, the building being always written first. If there is more than one similar department in a building, numbers may be added to indicate the different departments; thus in a rubber plant BA may stand for a pressroom in which miscellaneous sizes of tires are cured, and BA1 may indicate a press room in which only one size of tire is run, such as those tires used on the Ford or Chevrolet. Drawings, parts, and cost classifications may also be designated by letters. Unless a logical system is worked out, letters become unwieldy in a large institution having many items to be classified.

At least three systems utilize numbers for identification—the use of consecutive numbers, the assignment of particular groups of numbers to certain well-established classifications, and the Dewey decimal system. The use of consecutive numbers is simple and may be satisfactory in a limited way for such items as general notices to the plant. When the number of items is great, consecutive numbers are not satisfactory unless accompanied by a cross-indexing system for ease of reference.

The assignment of certain groups of numbers to established classifications is a well-known system and, when scientifically worked out, is capable of indefinite expansion and is entirely satisfactory. This system is widely used in accounting. A simple allocation of numbers might well be as follows:

1. Departments	1–199
2. Asset accounts	200–299
3. Liability accounts	300–399
4. Revenue accounts	400–499
5. Expense accounts	500–

By a proper combination of numbers a logical system can be built up that soon becomes generally known throughout the organization. Certain positions indicate specific classes or groups. For instance, the first two numbers usually indicate the class of machine and the last two the ma-

chine number within the class, as follows: 0501—automatic-feed turret lathe, 1; 0502—automatic-feed turret lathe, 2, etc. Every phase of the enterprise can be readily classified by proper analysis and thought. (See Appendix B for a detailed explanation of this system.)

The Dewey decimal system is best known in library science. It has been used in industry but has few if any advantages over the use of assigned numbers to certain classifications and has the disadvantage of increased possibility of error through misplacing the decimal point. This error may be obviated by omitting the decimal point and indicating its position by the use of zeros; thus 015 is used instead of .015. However, in such numbers as 00019 it is very easy to omit one of the zeros.

PART VIII

MATERIAL AND PRODUCTION CONTROL

CHAPTER 32

INVENTORY CONTROL

Types of inventories. The main types of inventories in most industrial enterprises are: (1) raw material, (2) material in process, (3) finished products, and (4) supplies. Supplies are often classified as raw material. To the individual manufacturer, raw material consists of all items which go into his product and on which he has not performed operations, such as brass rods, sheet metal, or parts purçhased from outside suppliers. Material that has not undergone any major change since its receipt is usually classified as *raw material. Material in process* is material that has been processed in part but as yet is not ready to be shipped to the consumer. Material in process may be in any stage of completion, from the material issued by the stores department but as yet having no operation performed upon it, to finished material still held in the production unit ready to be turned over to the stockroom or not yet reported to the control division as ready for shipment. *Finished products* have been completed and are ready to be shipped to the consumer. Where there is a separate stockroom or shipping department, the product is considered a finished product when it is turned over to this unit. *Supplies* are all the materials that are used as aids to production but are not part of the product itself. Such items as oil, sandpaper, and polishing compound come under this heading. Sometimes small tools such as knives and hack-saw blades may be classified under the general heading of supplies.

The need for inventory control. The stores and partly finished stock on hand often represent from a quarter to a half of the capitalized value of the business. Wastage, obsolescence, or poor purchasing may quickly wreck a concern through inventory losses. Poor control of materials is frequently accompanied by poor storeroom administration in a way that may easily throw out of balance any operation programs which have been adopted.

If the business is budgeted, or if only sales and production programs

are adopted, it is essential that an inventory control be set up which will provide material as it is needed but will not at the same time tie up large sums of capital which might be used in operating the program. No complete system of budgeting can be successful unless effective inventory control has preceded it. Otherwise production obligations cannot be met by the manufacturing department, at least within the allowed cost. The daily routine of cost accounting, with or without an administrative budget, demands that material be controlled accurately and intelligently.

Losses from inadequate inventory control. Losses from improper control of inventories include purchases in excess of needs, the costs of slowed up production resulting from material not being available when wanted, and losses through improper diversion of material, either wastefully or willfully. The losses due to excess purchases provide a continual argument for small stocks, and the losses due to production tie-ups furnish a strong motive for large stocks. It is between these two conflicting forces that a balance must be struck. Proper inventory control will reduce costs arising from any of the foregoing causes.

Excess purchases entail not only the losses in interest and inability otherwise to utilize tied-up capital, but also direct loss from depreciation on the material and frequently from obsolescence, which may be so great that high-priced goods will have to be sold for the price of waste or junk. Particularly in standard products, charts provide a means of eliminating expensive overpurchases. Overordering is costly on a stationary material market, and in a falling market it conceivably may lead to bankruptcy. Damage and deterioration due to overstocking must be reckoned with. Excess quantities frequently encourage poor storing and unnecessary transporting and handling within the plant, with consequent damage to materials and increased costs. Furthermore, many articles, such as foodstuffs, drugs, and rubber, deteriorate with age; this fact may mean a substantial loss of all materials purchased above relatively current requirements.

To promote smooth factory operation and to prevent piling up of idle machine time, proper material must be on hand when it is wanted. If material is not available in continuous-process industries, temporary shutdown of a large portion of the plant may result. In any plant in which operations, machines, and orders have been finely balanced, this will mean untold confusion. The storeroom is a service department, and prompt delivery of materials to the manufacturing floor is all-important.

Improper diversion of materials through excess use is commonplace in many plants; it has been eliminated in as many others. Frequently material is thrown away, lost, or damaged while in process, without any record providing a check. One cause of this condition is the plant's allow-

ing excess material to remain in the production department to be used on future orders, rather than having it returned to the storeroom. This practice is common in fabricating plants, where cartons of raw material, the product of other plants, are used extensively.

In such shops issuances are not closely checked in the storeroom or elsewhere against production orders, and thus standards of consumption are for the most part lacking. In other shops, if the workman damages material, he can usually receive an additional supply from the storeroom without much questioning.

Direct thievery, although important, is usually the smallest source of loss from improper material control. In some plants workmen have uncontrolled access to the storeroom. This freedom sometimes results in startling losses, especially of materials that are easily disposed of to pawnshops or junk dealers or that can be used in the workers' homes. To protect materials from thievery is an obvious function of any stores-control system.

Essential steps in inventory control. Effective inventory control, which, together with good methods of storeroom and purchasing-department operation, can eliminate most of these losses, requires the following steps:

1. Fixing minimum quantities, or ordering points, and maximum quantities, or amounts to order, on all materials.
2. Arranging a method for allocation of material to orders which are in process or are contemplated.
3. Creating stores accounts, which will control the storeroom and not be controlled by it.

Maximum and minimum quantities. No scientific approach is possible without establishing maximum and minimum quantities for all important items. If an ordering point and an ordering quantity are set, the maximum inventory will automatically be determined. *The ordering point* usually is not the minimum inventory, but somewhat higher than the danger point or minimum. It is sufficiently above the minimum inventory to allow for issuing the production or purchase order and for fabricating or processing in the plant or, if purchased, for delivery by a vendor. For control purposes the ordering point is more important than the minimum inventory. The *maximum inventory* is approximately the sum of the ordering quantity and the minimum inventory. It will exactly equal these two quantities if the ordered material is delivered just when the minimum inventory is reached. Such precision seldom is realized in practice, and as a result the maximum inventory is nearly always somewhat higher than the theoretical figure. The same is true of the minimum inventory. Under actual operating conditions the inventory may fall

below the minimum. This is a danger point and is a signal for a close follow-up to avoid a tie-up in production. When there are large numbers of articles, it will be well to divide them into broad classes, in all of which the individual articles will have maximum and minimum quantities controlled by the same factors. The factors which determine the maximum and minimum point for each article of stores may be divided into two broad groups. First is a group applying to all articles carried, such as general business conditions and the prospects of the particular business. Second is a group of factors directly dependent on the article itself. These are somewhat intertwined with the first group, but may cause special treatment for some particular material.

Predicted consumption during a given period, as indicated by general market conditions, by the state of health of the concern, and by the announced policy of the firm toward lines being manufactured, forms a basic consideration which is reflected in all other factors. In periods of increasing production and great market demand, ordering quantities may be increased, and the minimum frequently must be raised. If business conditions are the reverse, the minimum generally must be lowered. A major factor to be considered at the same time is the probable trend of prices in the commodities to be purchased. This trend may or may not follow general market conditions. Two more general factors peculiar to the business are the condition of its finances and available capital and the extent of storage facilities which are available. In considering this second factor, the cost of new storage facilities, or interest thereon, must be balanced against the cost of carrying inventories which the present storage facilities can handle. Changes in the line of product, particularly standardization programs in process of development, may easily be the most important of these factors which are general to all materials carried.

A number of factors peculiar to each article must be considered separately for each:

1. The consumption of that article over a past period must be considered in connection with the general factors just mentioned.

2. There is a profitable manufacturing or ordering quantity. The ordering quantity, particularly on special goods, indicates the profitable manufacturing quantity in the vendors' plants. These quantities can best be determined by experience and quotations. Ordering quantities must always be set with due regard to commercial usages.

3. Probable depreciation or obsolescence will influence the amount that should be carried in stock.

4. On small, inexpensive items the clerical cost of ordering, receiving, and payment of bills may cause an increase in the ordering quantity.

5. The time necessary to secure the article after requisitioning must be considered.

On purchased goods for which there is a regular source of supply, the time required will include the period after the shipping date, as promised

by the vendor, during which the article is being transported to the user's plant. On worked materials, it will be dependent on the time taken to work up a manufacturing order for the ordering quantity within the plant itself. The work situation in the plant will greatly influence the time required for the plant to produce a given part or assembly.

The first step in inventory control has been taken when the ordering point and ordering quantity have been set. On standard products, made to a manufacturing schedule, these may often be set in a much simpler way by establishing production requirements for a given length of time as the ordering point, and production requirements for another stipulated time as the ordering quantity.

Computing economic lot sizes. The minimum unit cost for a given part or material is the desired goal of ordering on the basis of the economic lot size. This point occurs when the total preparation costs for the quantity to be produced are equal to the total average inventory-carrying charge. One large manufacturer in Chicago developed a formula for the control of manufacturing lot sizes, and then the management reduced these lots arbitrarily twenty-five per cent as a matter of being conservative and for the reduction of inventories. The critic would say that this procedure is not scientific, and this is true. On the other hand, it has much to commend it over no method of control other than mere custom or past experience that has not been critically evaluated. A formula that is satisfactory for all plants has not as yet been developed. This situation is not essentially different, however, from that existing in many other phases of scientific management. Even within the same plant, routines must be modified to meet the requirements of the specific condition to be served. The same flexibility must exist in connection with the formula used for the determination of the economic lot size to be manufactured.

The formula used by the manufacturer mentioned in the preceding paragraph is as follows:

$$Q = \sqrt{\frac{2PR}{CI}}$$

in which Q = economical lot quantity in units.

P = preparation costs in dollars, consisting of the clerical cost of preparing the order as well as setup and dismantling costs.

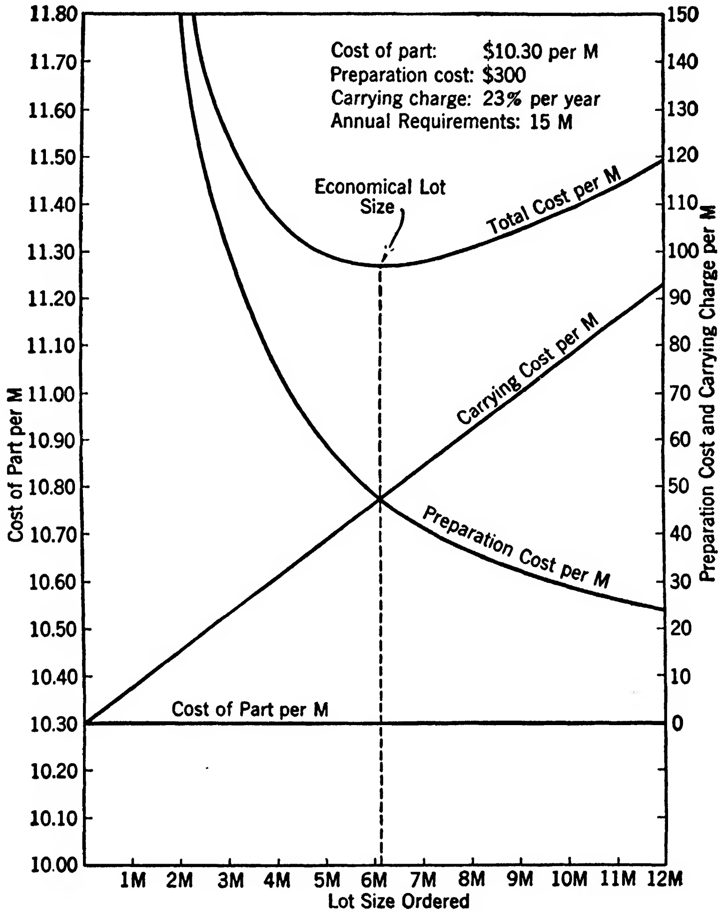
R = requirements in units on an annual basis.

C = cost of part in dollars per unit.

I = carrying charge in percentage per year.[1]

[1] See John MacDonald Gifford, *Procedure Control of an Electrical Manufacturing Organization,* p. 76 (thesis, School of Commerce, Northwestern University, 1939).

The preparation costs are made up of two parts, namely, (1) the ordering cost, which includes all planning and clerical costs, and (2) the machine setup cost. The requirements in units on an annual basis are usually taken from the master budget or master schedule. This figure



Courtesy, John Gifford

Fig. 32.1. Unit costs, showing the economical lot.

can be only an estimate. The carrying charge (I) expressed as a percentage of the cost of the economical lot includes such items as interest on the investment in inventory; taxes; stockroom expense—storage, etc.; depreciation; and obsolescence. This carrying charge is frequently as high as twenty per cent or higher. Figure 32.1 illustrates the decreasing cost of preparation with increase in the size of the lot, as well as the increasing carrying cost of the increased lot.

Data regarding the economical lot size for a given concern are frequently expressed in the form of a chart from which the desired lot size can readily be taken. As was stated at the beginning of this discussion, the economical lot-size formula is not of universal application but must be derived from the facts in a given situation. In any case the use of the economic lot is of value primarily when ordering for stock and not in continuous manufacturing.

The balance-of-stores sheet. The other steps in inventory control are taken through the use of a balance-of-stores sheet, such as that in Fig. 32.2. Such a sheet actually serves as a basis for controlling the storeroom and is not merely a record of material on hand or a perpetual inventory. Many forms of balance-of-stores sheets have been devised to meet individual operating conditions, but all that furnish the necessary control are uniform in providing four important balance columns, which actually, together with the maximum and minimum which have been set, control the inventories. These balance columns (see Fig. 32.2) are headed "Ordered," "Balance on Hand," "Apportioned," and "Available." "Apportioned" is frequently called "Applied on Orders." Under either name, it denotes that material which has been allocated to given manufacturing orders but has not yet been withdrawn from the storeroom.

The Apportioned column insures that steps have been taken to have the material available when wanted for manufacture and successfully eliminates the practice of relying on the same lot of material to fill two orders. Unless materials are applied as delivery dates are stated and schedules for manufacture are prepared, it becomes likely that the planning department will depend upon the same materials for two purposes. The Available column indicates the amount of material which is still available for assigning to orders. The last balance in this column, rather than the balance in the On Hand column, is continuously compared with the stated minimum to determine when to order. If this were not done, goods well above the minimum might be on hand but might be ordered into production immediately for orders already in the plant, to such an extent that the danger point might be reached and passed long before a new supply of goods could be secured. This balance sheet provides a continuous check of its own accuracy, inasmuch as Column 1 (Balance Ordered) plus Column 3 (Balance on Hand) should always equal Column 5 (Balance Apportioned) plus Column 6 (Balance Available) after any transaction has been entered.

To indicate clearly the operation of this sheet, which is basic in inventory control, the accompanying illustration will be explained. The article, 2-inch hollow steel tubing, quality specification "B," has had its minimum set at 800 feet, and the ordering quantity at 4000 feet. The

KIND OF UNIT *Foot* DESCRIPTION *2" Hollow Steel Tubing, "B"* MINIMUM *800* QUANTITY TO ORDER *4000* SYMBOL **SST2B**

BALANCE OF STORES

1 ORDERED		BAL.	2 RECEIVED			3 BALANCE ON HAND			4 ISSUED				5 APPORTIONED		BAL.	6 AVAILABLE	BAL.	
DATE	ORDER NUMBER	QUANTITY	DATE	QUANTITY	VALUE	QUANTITY	VALUE	UNIT VALUE	DATE	ORDER NUMBER	QUANTITY	VALUE	DATE	ORDER NUMBER	QUANTITY	DATE	QUANTITY	REMARKS
						6/14 1500		.35								6/14	1500	
						900			6/18	3726	600	210 00					900	
						600			7/10	3914	300	105 00					600	
7/11	1487	4000														7/11	4600	
													7/20	3982	1200		3400	
						300			7/28	3982	300	105 00		"	900			
		0000	7/30	4000	1600 00	4300		.40										
						3700			8/8	"	600	240 00		"	300			
													8/20	4071	2100	8/20	1600	#4071=1800
						3400			8/22	"	300	120 00		3982	1800			
						2200			8/27	4124	1200	480 00					400	
8/28	1516	4000														8/28	4400	
						1600			9/11	4071	600	240 00			1200			
		0000	9/14	4000	1520 00	5600	2160 00	.39										

FIG. 32.2. Balance-of-stores sheet.

maximum is therefore 4800 feet. On June 14, when this sheet was opened, there was on hand a balance of 1500 feet, which was also available to be apportioned. The unit value of this material, as brought forward to this sheet, was 35 cents per foot. The first transaction was an issue to the shop of 600 feet, without previous apportionment. The next transaction was a similar issue of 300 feet, which brought the Balance Available below the minimum, and hence an order for 4000, the ordering quantity, was entered. Upon ordering, this amount is considered immediately available for apportionment, although it is not yet in the plant, and hence not ready for issue. (On commodities or in times when prompt delivery cannot be expected, it is unwise to consider material which has been ordered as available until it has been shipped.) On July 20, production order No. 3982 was entered, calling for 1200 feet of this article, which was immediately apportioned to this order, and taken from the Available column, although the order was not yet placed in production. On July 28, 300 feet of this amount was issued to the shop for production, and therefore deducted both from the Balance on Hand and the Balance Apportioned. Next, on July 30, the material on order arrived, and was deducted from the Balance on Order and added to the Balance on Hand. The new material cost 40 cents per foot, and there was so little of the old supply on hand that the unit value of all the material was entered as 40 cents. The next transaction called for the issue of 600 more feet of the material apportioned to production order No. 3982, which was deducted from the Balance on Hand and the Balance Apportioned. On August 20, production order No. 4071 was received, requiring the apportionment of 1800 feet, and making the Balance Apportioned 2100 feet, and the Balance Available for apportionment 1600 feet. On August 22 the remaining 300 feet apportioned to order No. 3982 were issued to production, again reducing the Balance on Hand and the Balance Apportioned. On August 27 an unexpected order (No. 4124) was received, calling for immediate production of articles requiring 1200 feet of tubing. This order was placed in production without delay, the full requirements being issued to the shop on the same day that the order was received. This again brought the Balance Available below the minimum, and an order was placed the next day for 4000 feet, despite the fact that there still remained in the storeroom 2200 feet, 1800 feet of which, however, was apportioned to order No. 4071. On September 11, 600 feet were issued to the shop for order No. 4071, thereby reducing the Balance on Hand and Balance Apportioned columns. On September 14, the 4000 feet on order arrived, at a unit price of 38 cents per foot, thus increasing the Balance on Hand to 5600, while the Balance Available for apportionment remained at 4400. The total value of the 5600 feet on hand was

DESCRIPTION Switch (Radio-Phone) CARD NO. 1 PART NO. B-55500-1

ORDER NO.	MODEL NO.	QUANTITY	USAGE	TOTAL USAGE	ORDER NO.	MODEL NO.	QUANTITY	USAGE	TOTAL USAGE	ORDER NO.	MODEL NO.	QUANTITY	USAGE	TOTAL USAGE	ORDER NO.	MODEL NO.	QUANTITY	USAGE	TOTAL USAGE	INSTRUCTIONS
10	554	31879	1	31879																

TOTAL REQUIREMENTS	TOTAL ON ORDER
31,879	33,000

RECEIPTS				P. O. NO. / QUAN.	50818 / 19,000	52304 / 17,350							SCRAP			MONTHLY RECEIPTS & DISBURSEMENTS				STOCK STATUS
DATE	REC'R. NO.	P. O. NO.	QUAN. REC'D	CUM. QUAN.	BALANCE	BALANCE	BALANCE	BALANCE	BALANCE	BALANCE	BALANCE	BALANCE	DATE	QUAN.	CUM. TOTAL	MONTH OF	QUAN. USED	CUM. TOTAL	RECEIPTS	
12-20-45	52304	Invr.	1250			18600										Jan.			9794	9794
1-17-46	130202	50818	4775	4775	14225											Feb.	46	46		9748
1-15-46	130026	50818	480	5255	13745											March			15468	25216
1-16-46	130027	50818	1440	6695	12305											March	5025	5071		20191
1-19-46	131057	50818	2880	9575	9425											March	50	5121	Adjust.	20141
1-22-46	131241	50818	219	9794	9206															
3-11-46	137315	50818	1284	11078	7922															
3-13-46	137505	50818	2816	13894	5106															
3-18-46	138171	50818	5106	19000	0															
3-20-46	138527	52304	6262	25262		12338														
3-31-46	Inventory			20143	0	12338							7-12-46	107	107	3-31-46	Inventory			20143
5-8-46	150032	52304	1100	21243		11238										4-12-46	25	25	Req. 10210 Service	20118
5-9-46	150462	52304	3300	24543		7938										April	4085	4110		16033
5-13-46	150637	52304	6597	31140		1341										May			12857	28890
5-23-46	151960	52304	1100	32240		241										May	4741	8851		24149
5-23-46	151961	52304	760	33000		519										June	4845	13696		19304
																7-25-46	50	13746	Req. 6231 Service	19254
																8-1-46	50	13796	Req. 6242 Service	19204

VENDOR	P. O. DATE	P. O. NO.	QUANTITY	PRICE	VENDOR	P. O. DATE	P. O. NO.	QUANTITY	PRICE
Oak Manufacturing Co.	9-27-45	50818	19,000						
Oak Manufacturing Co.	11-19-45	52304	18,600						

1813 5M 2-46 TYPO

Fig. 32.3. Material control card of International Detrola Corporation, Detroit.

then \$2160. This series of transactions illustrates the more important entries made upon this sheet and shows how intelligent control of inventories is possible, allowing in advance for all production needs without unnecessarily tying up capital in material on hand. It will be noted that, after each transaction, Column 1 plus Column 3 equaled Column 5 plus Column 6.

The balance-of-stores sheets may be operated by any division of the business which the organization may feel is best from its standpoint. They may be kept in the general accounting office, in the storeroom, or in some portion of the production office, preferably the planning department. Since the operation of the balance-of-stores sheets is primarily a function involving thinking ahead, and since it is so closely associated with control of production, the most logical place to operate it is a planning department if there is one.

The single stock-control card of the International Detrola Corporation takes the place of the four cards formerly used by the corporation.[2] It will be observed that this card is used in a mass-production industry which does not experience the complicated problems of a job shop. Entries of shipments received are made when they arrive and are inspected (see Fig. 32.3). Daily usage is not entered, since total usage can be determined at any time by multiplying the number of pieces per product by the number completed to date. The cumulative total under the *receipts columns* is entered monthly in the *monthly receipts and disbursements* columns under the heading *receipts*. From this figure the *cumulative total used* is subtracted to obtain the *stock status*. A check of the stock status against the production schedule gives a quick, accurate forecast of the stock needed for the period in question.

Visual control of inventories. The L. C. Smith and Corona Typewriters, Inc., of Groton, New York, has developed a visual method of controlling raw materials and finished-parts inventories (see Fig. 32.4). This control board is 7½ feet long and 6½ feet high. The horizontal lines running across the board represent weeks. These lines are numbered from the bottom up by attaching a cardboard strip to the left side of the board. This strip also has the date by each line. Running vertically are a series of sets of different colored strings. These strings run clear around the board and are separated from each other by brads in the top and bottom board spaced ¼ inch apart. Each string running around the board is composed of two parts; one-half of the length is white and the other half is blue for the right string, red for the middle one, and green where a third string is used in the set. Where the colored

[2] See *Factory Management and Maintenance,* Vol. 104, No. 7, p. 105, for a detailed description of the use of this card.

string is tied to the white string, a knot is made. These knots as they are moved up or down the board graphically portray the status of the inventory. Across the face of the panel and outside the strings are three horizontal wooden sticks about 1/4 inch wide, 1/8 inch thick, and about

Courtesy, L. C. Smith & Corona Typewriters, Inc.

FIG. 32.4. Visible-index-inventory control room, L. C. Smith and Corona Typewriters, Inc., Groton, N. Y.

3½ feet long. These three sticks are clipped at the ends to the same strings so that they may be raised or lowered as a unit. The top stick is painted green, the middle one yellow, and the bottom one blue. The bottom stick is located on the board at the height that corresponds with the current calendar week and is moved up one space each week. The yellow or middle stick is located at a 4-week interval above the current week. This is the period allowed the planning department for issuing manufacturing orders, bills of materials, and instructions. The third or

top stick serves as a signal to the inventory clerk to place an order on the purchasing department for the stock in question when it, in its upward movement, overtakes either the green or the red knot.[3] The horizontal cardboard strips thumbtacked to the board about halfway up bear information about the identity of the stock and its use.

Other companies use various visible index cards filed in the traditional index file or in some instances in a roller type of file. It would be difficult to claim which type is best. Each fits a peculiar need and serves that special situation.

Control of supplies. The same care should be exercised in disbursing supplies as in issuing regular production materials. This is true particularly of such items as sandpaper, knives, and others that can readily find their way into workers' lunchboxes. Frequently there are special storerooms for maintenance supplies as well as for office supplies. Both of these storerooms may not have sufficient calls to require a full-time storeroom man. In such cases the department clerk or someone else in the organization may be delegated to this task for part time. A very important function of the storekeeper of supplies (or of regular production materials) is the preparation of a periodic summarized report of slow-moving or obsolete materials. This report may well be duplicated and sent to all persons who may aid in disposing of this material. Frequently slight adjustments may make possible the using of obsolete material or the temporary substitution of a slow-moving item for a regular one. A close control over repair materials serves as a real aid to the purchasing department and frequently prevents overordering. Again such a control helps to eliminate expensive delay by insuring that certain items regularly called for will be available.

Taking inventory. An inventory may be taken by an actual physical count of all items at approximately the same time, by a progressive taking of physical inventory, by balancing the perpetual inventory records, or by a combination of these methods. The disadvantages of the total physical inventory may be summarized as follows:

1. It is taken only once or twice a year because of the cost and inconvenience involved.
2. It is usually necessary to shut down the productive processes of the plant for the period during which the inventory is being taken.
3. Accuracy is usually impossible. Speed is generally the paramount consideration, and no matter how highly organized the inventorying force, there are usually a number of omissions and duplications.

[3] The third stick is located above the second stick a distance equal to the interval, usually from 8 to 16 weeks, required by the purchasing department to place an order and secure delivery of the material.

The second method that may be used for checking with book records is the progressive count. In the larger companies one or two men, or as many as may be required by the particular business, may be engaged continuously in counting materials on hand. In a smaller plant the services of a clerk in his spare time each day may suffice. In either event, at given intervals of a few months all the material is checked. Checkers start at one part of the storeroom and make the round of the department, checking all the items in a certain number of bins each day, and comparing them with the balance shown on the bin tag and in the stores ledger.

The third, and now practically universal basic, method of inventorying is through a book record or running inventory, such as the balance-of-stores record already described. This method provides a running inventory record of every article which is kept in the storeroom. Its advantages are the following: (1) The total inventory is found simply by taking off a trial balance of the stores ledger; (2) a record of the issuances of materials is afforded, and this may be followed up to see that the materials were actually used for the purposes for which they were withdrawn from the storeroom.

Even when a perpetual inventory is provided, the taking of physical inventory cannot usually be completely dispensed with. Neither banks nor the Internal Revenue Bureau will accept unchecked book inventories, and from the standpoint of the business itself such practice is unwise. A book inventory is never one hundred per cent correct, and it is frequently far from this ideal, because of both clerical errors and unavoidable discrepancies between issues and issue tickets. In order to meet this situation some physical check of the book inventory is provided. Such a check does not involve closing the plant to take inventory but may be performed in one of the following ways.

One method is to check material as it reaches the minimum which has been set. The taking of physical inventory at the low limit requires little time and work. If there are bin tags, it can be done by the storekeeper on his own initiative as he notices that the balance on the tag has reached the minimum. If there are no bin tags, the balance-of-stores clerk can make up a daily list of articles which his records indicate have reached the minimum, and this list can be made the basis for checking. Special provision may be made for checking items which have not reached their low limit during a period. Of course, in such cases the maximum or ordering quantity has been set too high and should be corrected.

A well-ordered storeroom and system of storeroom operation can be thrown into utter confusion by two days' use of lax methods. There will be frequently a temptation to depart from the procedure which has been

set up because of a rush of incoming material or because of a sudden need for certain material in the shop. The slight time momentarily saved in deviating from the standardized procedure will be more than nullified by the complications and losses which will ensue.

Position of inventory control in the business. No method for the control of stores is a substitute for business judgment. In fact, judgment must be carefully exercised in carrying on the control methods just described. No methods as yet devised will automatically increase a minimum on a rising market or decrease it on a falling market. Methods, however, provide a useful tool for the management and are a means to an end. Together with the balance of stores sheet, they form a very satisfactory basis for good inventory control. They must, of course, be supplemented by other management steps.

CHAPTER 33

STOREROOM OPERATION

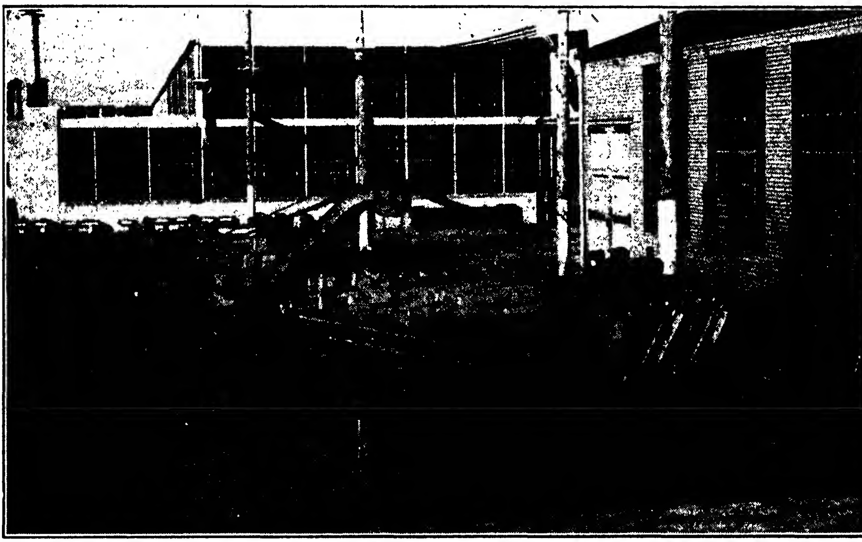
Locating the storeroom and storage space. The storeroom should be centrally located in relation to the production floors on which the material is used. The storeroom may consist of one room, one building, or a main room with subsidiary rooms advantageously located for the storage of special materials or materials for particular departments. The nature of the industry, the nature of the material, the site occupied, the situation and size of the buildings, and the arrangement of departments within the building must determine storeroom location. For instance, ease of receiving through the use of gravity may place the storeroom for bulk materials far from the point of their use, which may be reached by means of overhead cranes or conveyors at a lower cost for small lots of materials than for the large lots in which the materials are received. The use of material-handling equipment[1] has made storeroom location more flexible, as such equipment can be used to transport materials either to subsidiary storerooms or from a central storeroom to operating departments.

The location of the storage space will depend on the nature and value of the materials to be stored and the rapidity with which amounts will be received and issued, as well as upon the point at which they will be placed in manufacture. Material such as paper pulp is too bulky and used too rapidly to be stored in bins. However, the storage problems connected with such materials can well be studied. For instance, paper pulp, instead of being stored in huge piles involving rehandling when needed, can be placed on platforms to be picked up by transfer trucks, each platform containing a standard quantity properly tagged to indicate lot numbers and specifications.

Heavy materials generally must be stored on the ground floor, whereas light materials can be easily handled and can be fitted into almost any location that is otherwise desirable. Figure 33.1 illustrates the use of outside storage space for heavy castings. When castings have to be aged, outside storage is both advantageous and economical. Materials that are easily broken require facilities for protection, and this protection must take precedence in fixing the storage place. Similarly, valuable material

[1] See Chapter 13 for illustrations of the various types of handling equipment.

necessitates consideration of not only location but also safety. Some articles can be stored only under particular temperature conditions, and the storage place must be determined with temperature regulation in mind. Inflammable material often demands a separate storage space that not only will protect the material itself, but also will reduce the fire hazard for the remainder of the establishment. This may mean that a sepa-



Courtesy, "Factory Management and Maintenance"

FIG. 33.1. Outside storage of steel castings saves valuable manufacturing space inside. These medium castings beside the rough sanding building (*right*) are delivered by electric trucks to the planer department (*main building in background*) as rapidly as needed.

rate building will have to be erected, or a sort of fireproof vault provided within the storeroom, possibly communicating with the remainder of the storeroom through double firedoors.

Any plan for the location of a storeroom must be flexible enough to allow for growth and other changed conditions arising over a period of years. If such conditions cannot be foreseen, or if the material stored will be used only for a short period, it may be profitable to consider the construction of temporary storage facilities that can be changed readily.

Types of materials stored. Storage space in a manufacturing enterprise must be provided for the following types of materials:

1. Raw materials, properly termed "stores."
2. Supplies—materials used indirectly in production, such as oil, expendible tools and auxiliary items, nails, glue.

3. Partly finished materials, or stores on which some work has been performed. These are usually termed "worked materials" and may include finished components awaiting assembly or shipment to customers as replacements. Purchased components also fall in this general category. These may include any item made in the factory, as well as screw-machine products, etc.

4. Finished products awaiting shipment, properly termed "stock." Storeroom arrangement and operation must take into account the varying problems presented by these separate classes of goods. The term "stockroom" is often used to refer to the place where finished goods awaiting shipment are stored.

Layout of the storeroom. The arrangement and layout of the storeroom involve allotting space for more than the actual storage of the goods. For smooth storeroom operation it is necessary that a section adjoining the entrance to the storeroom be reserved for the receipt of material as well as for its inspection before storage. Also, space must be provided for material withdrawn for issue to the production floors but not yet removed from the storeroom. Such space will enable the man in charge of the storeroom to work up his issuances in advance, in order that there may be no delay when the goods are actually required.

The area to be provided for storage purposes will be worked out during the study of the location of the storeroom. Too much space will add to the indirect cost of storing the material. On the other hand, insufficient area will increase costs because of the congestion resulting. Lack of space in the storeroom will often lead to a reduction of the quantities that may be carried, so that production is seriously hampered. The amount of storage space to provide is easily determined when a standard product is being manufactured, but not when numerous products of varying kinds are being produced.

One of the most essential features of storeroom layout is adequate aisles and passageways, which will permit materials to be brought in and taken out in the most expeditious manner. For bulk storage the storage areas and aisle spaces may be marked on the floor with paint. The layout of aisles will vary according to the needs of each storeroom, but in general it may be said that main aisles should allow the passage of two trucks and should vary from 6 to 8 or more feet in width, whereas other aisles will usually have to allow for only one truck. In blind aisles running up to a wall, allowance may have to be made for the turning of the truck. Where the articles stored are generally carried by storesmen, the width of the aisles between the rack has been standardized at 30 inches in some storerooms. Figure 33.2 indicates the proper relationship of aisles to storeroom layout. The desirability of a central location for receiving and issuing, as well as assembling stores for stowing or issuing, is also shown.

Location of material in the storeroom. The student of storeroom operations should keep in mind the universality of the principles involved. The wholesale house, factory branch, and mail-order house are faced with the same problems as the manufacturing establishment. There are two main ways of arranging a storeroom: (1) directly by classification; (2) by index. Both are widely used.

If material is arranged by classification, it should be stored in the classification order. If the mnemonic system is being used, the first racks

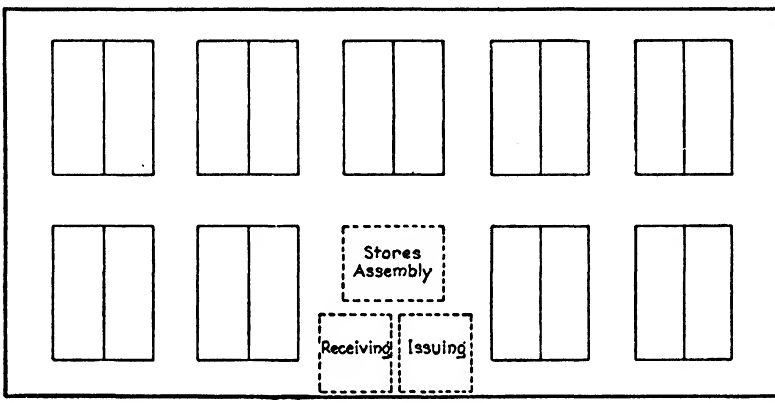


Fig. 33.2. An effective storeroom layout. Windows will be in exterior walls opposite aisles.

should include all those articles whose symbols begin with F, or whatever other letter is first, and the last racks should have stored on them articles whose symbols begin with W, or whatever other letter is last.[2] All intermediate racks should be alphabetically arranged, and a system should be developed for the alphabetical arrangement of each of the racks themselves, so that an article of stores may be found in the rack as a word may be found on the page of a dictionary. Bulky goods which cannot be stored by symbol are put in a convenient place, and a tag is hung at the point where the symbol would appear on the racks, giving the location of the material.

This arrangement of materials may be best illustrated by indicating the way in which it may be worked out in a particular plant. At the end of each rack on a central aisle, keyboards are placed which indicate the range of the contents of the rack. For instance, one of these keyboards may read SVZM-SVZY. This immediately indicates that all articles of stores whose symbols are alphabetically between these two

[2] See Chapter 31, "Classification of Business Details"; also Appendix B.

limits can be found in this rack, and this fact is used in much the same way that the tabs on the side of a dictionary are used in finding the ap-

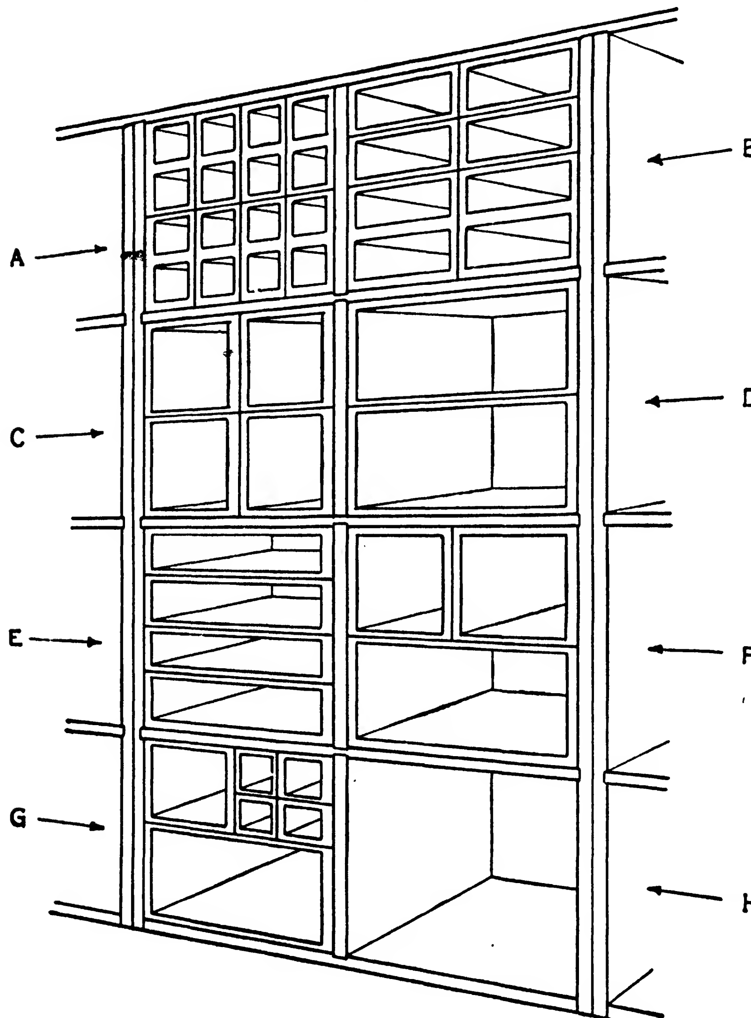


FIG. 33.3. Storeroom bin arrangement. Flexibility is gained by the use of wooden bins.

proximate location of a word. Each rack is divided into divisions, and these into sections and subsections, as is indicated in Fig. 33.3, which is an illustration of a main division. In stowing and locating material, each division is read separately, beginning with the upper left-hand corner

(Section A), then across to Section B, down to Section C, and so on until Section H is reached.

A storeroom having its material so arranged is not dependent on one man's recollection of where he has placed certain material. The plant would not be greatly handicapped even if the whole storeroom force were to leave suddenly. Arrangement by classification can be utilized, however, only where there is no rapid change in goods handled. Under any circumstances it has certain very definite disadvantages:

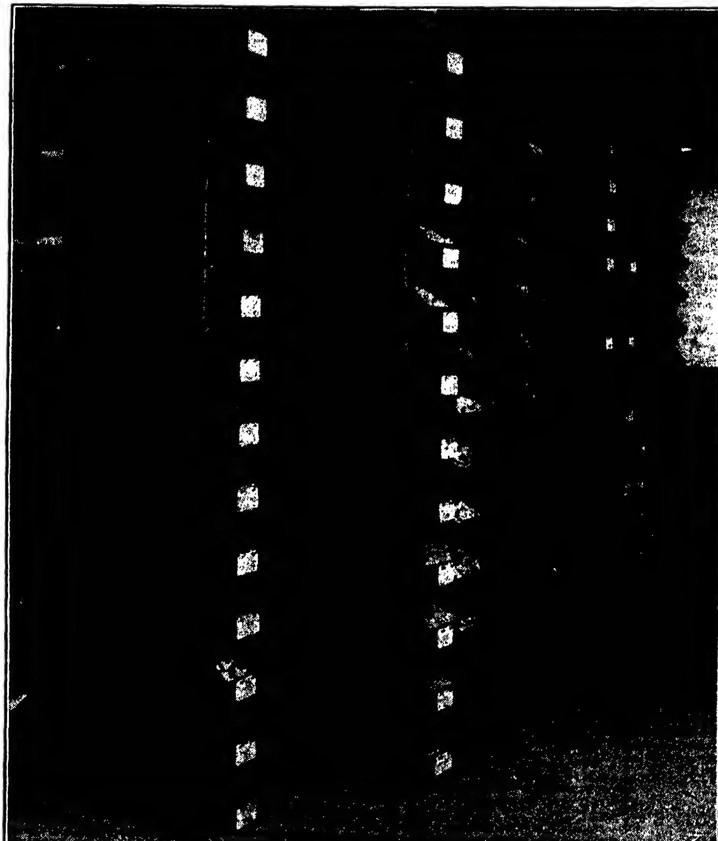
1. A large amount of space (twenty to twenty-five per cent) must be left in each portion of the rack to allow for expansion.
2. The goods most frequently issued cannot be placed near the issue window without breaking down the scheme of arrangement.
3. Certain goods, such as unwieldy materials or very heavy articles, can under no circumstances be stored exactly by symbol.

The second successful method of arranging a storeroom is by index. The materials in the storeroom are arranged in the manner most convenient for storage and issue, and then an index of material location is developed. In the index the material is arranged by symbol, and the location in the storeroom noted next to the symbol. This method necessitates designating the racks, rows, and sections in some manner that will allow the bin location to be expressed in the form of a symbol also. The racks may be lettered, and the rows in the rack are numbered, beginning from the bottom. Finally, each row in the rack is marked off into numerical divisions which may or may not correspond with the bin arrangement. In designating bin locations, the row is used as the first digit, and the division number as the last two. Thus, if the index indicates that an article can be found at D 408, the article is in rack D, row 4, position 8. Usually no attempt is made to number bins under this plan, which is particularly satisfactory if steel bins are used.

For the storage of large articles which cannot be placed in bins, the storage floors may have each bay and section lettered or numbered so that the locations may be recorded in much the same fashion as if the articles were stored in bins. Such symbols are frequently painted on supporting columns or suspended from the ceiling.

The chief disadvantage of arranging a storeroom by index rather than by classification is that the index must be consulted before an article can be found. If the stores are well controlled, this is not important, for the bin location can be inserted on the stores issue at the time it is written. Another disadvantage is that the men filling orders, especially when the parts handled are dirty, have difficulty in keeping the index cards clean and usable.

The advantages claimed for the arrangement by index are: (1) Stores can be so arranged that those which move fastest are nearest the points of receipt and issuance; (2) no rearrangement of the storeroom is necessary as new articles to be stored are brought in or storage of certain old



Courtesy, International Detrola Company, Detroit

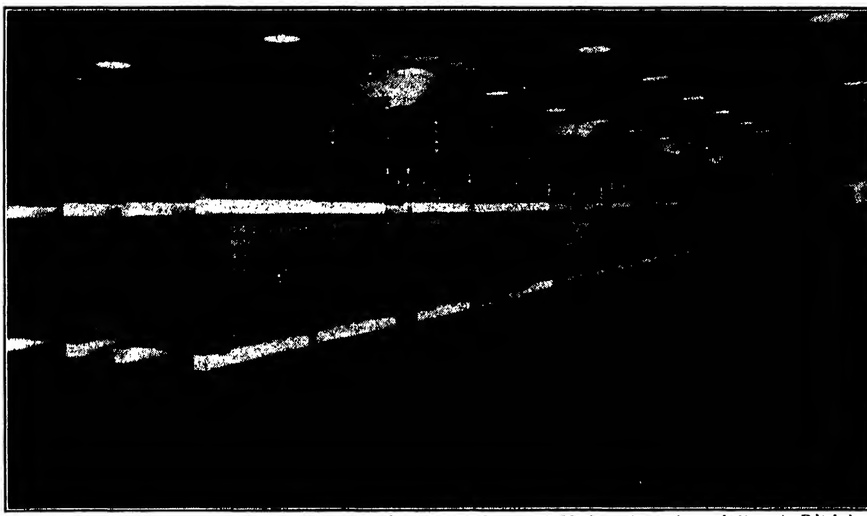
FIG. 33.4. Tote pans used for storage in the storeroom.

articles is discontinued; (3) goods can be stored with full regard for their special requirements.

Types of bins. Wherever possible, and always where large numbers of small articles are handled, racks containing bins should be placed back to back, making material accessible from aisles running between the rows and thereby economizing storage space.

Obviously, the nature of the stores will determine the size and method of subdivision of the bins, but some such plan as illustrated in Fig. 33.3,

which shows the use of standard wooden sections, should be adopted. For purposes of flexibility some such unit should be devised to fit the particular conditions encountered. In this illustration each 2-foot division can be used as a whole for the storage of materials, or it may be subdivided by inserting units or smaller bins. Thus one compartment is filled with sixteen boxes or bins known as sixteenths. The construction of these boxes is such that their outside measurements are equal, making



Courtesy, General Motors Truck and Coach Division

FIG. 33.5. Skid boxes used for storing material. Note the tiering made possible by the use of a high-lift truck.

possible the placing of sixteen of them in a division. The sixteenths will therefore be approximately 6 inches square outside. Eighths, quarters, and halves are also used.

Both wooden bins and steel bins constitute very satisfactory storage arrangements. When standard lots of small materials are frequently issued, the idea of using tote boxes and skid boxes as bin compartments or storage racks should be considered. Figures 33.4, 33.5, and 33.6 show tote boxes, skids, and steel bins. Steel shelving occupies less space than does wooden shelving, but it is more expensive. The original cost of the steel bins per cubic foot of storage space will ordinarily be higher than that of wooden bins. The better appearance and the sanitary and fireproof features of steel bins often cause their adoption.

Figure 33.6 illustrates a well-laid-out storeroom utilizing steel bins. Although such bins are of varying sizes, they are rarely changed, after being set up, except by inserting or removing dividing partitions. The

rows are composed of standard steel shelving. Figure 33.7 illustrates an orderly arrangement of small tools and supplies in special wooden racks and bins.

Many materials, such as bar stock and automobile drive shafts (see (Fig. 33.8), cannot be stored in the type of bins illustrated, and special

Courtesy, General Motors Truck and Coach Division

FIG. 33.6. Standard steel bins used for storing parts awaiting use on the assembly line. Note the protective device to shield the bins from the electric trucks that use the aisles.

provision must be made for their storage. Bar stock is sometimes stored by placing it horizontally on the sides of racks shaped like an A and having hooks on the sides to hold the stock, or by leaning the stock vertically against such A racks. Automobile drive shafts are ordinarily suspended on special racks to prevent bending.

Special storage also includes storing articles in the original package. Where there is a heavy turnover of small articles and the container fits in with the general storeroom scheme, it is sometimes advisable to store the articles in their original containers. On the other hand, this practice must be carefully controlled, since it is usually cheaper to break original packages when they are received than when the storeroom men are in a

hurry to make issues. On the other hand, many items may not be opened in the storeroom but sent to the assembly line in the original container.

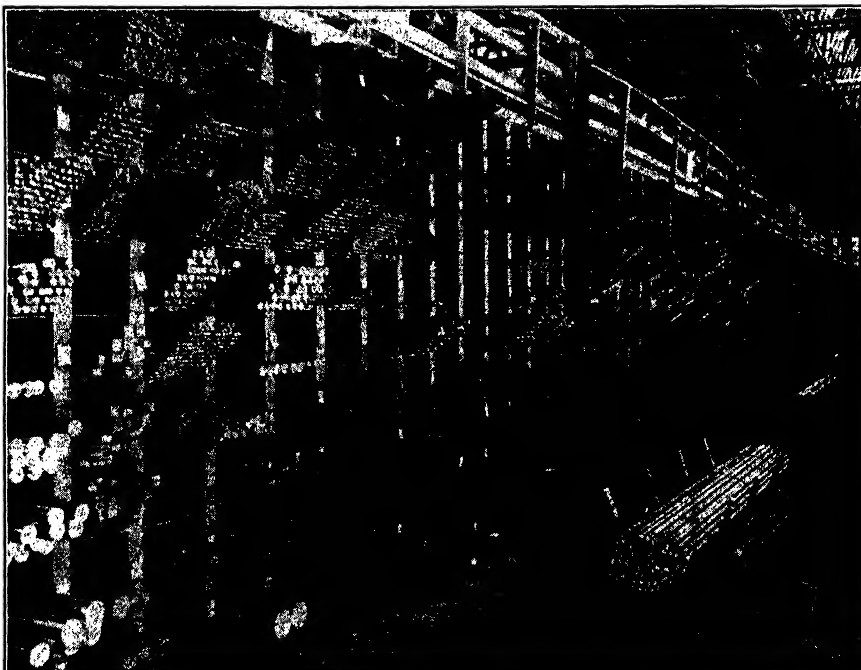
A few storerooms use the double-bin system, providing two bins for each type of material. It is evident that the double-bin system generally

Courtesy, Beech Aircraft Company, Wichita

Fig. 33.7. An orderly storeroom for tools, supplies, and small parts.

requires more space, but those who use it believe that this additional space is not a serious enough factor to overbalance the advantages in its favor. The double-bin system provides an "in" and an "out" bin for each article. While the material in the "out" bin is being drawn for use in the factory, newly received goods are being placed in the "in" bin. When the "out" bin is empty, withdrawals are begun from the other bin, which is now tagged "out," and the empty bin becomes the receiving bin.

The double-bin system prevents the accumulation of old material in the bottom of a bin, since it is used up before the new material is issued. This feature is of special benefit with material which is likely to deteriorate. Another advantage of the system is that it provides a continuous physical check on the material to compare with the records, and this check can be made and is made each time one of the bins becomes



Courtesy, General Steel Warehouse Company, Inc., Chicago

FIG. 33.8. Special racks for storing steel bars and other long items.

empty. This system is successful only when the kinds of materials carried in stock are more or less constant. When the amount of material of a given kind changes considerably, or the material is carried only intermittently, the single-bin system is generally better because of the saving of floor space. The single-bin system is far more extensively used. Most of the advantages of the double-bin system for small items may be secured by placing the minimum quantity from the new shipment in a small bag. The old material may be emptied into a container, the new material put at the bottom of the bin, the old material placed on top to be used first, and the small bag of minimum quantity placed in the back of the bin. Occasionally bins with a sliding partition similar to the par-

tition in a letter file are used. The old material is placed in front of the sliding partition and is used first.

Auxiliary storeroom equipment. When bins are used, one perplexing storeroom problem, and one that frequently prevents the use of the full height of the storeroom, involves reaching the upper tiers of bins. The general practice is to use steps or ladders, but these are continually getting in the way and blocking aisles; ladders, moreover, cause accidents, because the worker tends to lean too far to one side rather than move the ladder. One stores manager has developed the practice of arranging the bins in such a manner that the compartments at the bottom are large enough to receive heavy or bulky material, whereas those higher up decrease in size as they increase in height. For instance, at the top of the first row the depth is reduced by one board, or a foot. This forms an offset that is usable as a platform in reaching the bins above the second tier. From this the workmen have easy access to material 5 to 6 feet above, thus making it possible to reach goods to a height of 8 to 9 feet without the use of a ladder or steps. Under certain conditions, however, ladders may be necessary, and when they are, those on trolleys have usually been found to be the most satisfactory.

Various types of material-handling equipment have been developed, particularly for storeroom use. In nature they are similar to the material-handling equipment for general use described in Chapter 13. Counting scales, appropriate push trucks for collecting material from the bins, and similar aids facilitate storeroom operation.

Keeping stores records. If balance-of-stores control is carried on elsewhere than in the storeroom, a minimum of stores records should be maintained in the storeroom itself. The storekeeper can, nevertheless, be of great assistance in carrying a share of the load of controlling inventories if he studies conditions within the storeroom and the shops, ascertains needs, and cooperates with the purchasing department and the balance-of-stores clerk. Insuring smooth and prompt operation of storeroom routine will constitute his greatest service toward good inventory control.

Someone must provide a positive check to insure that articles on hand will not fall below the designated minimum. A check can be provided in the form of a bin tag on which records of receipts and issues can be maintained. If a separate bin tag is utilized for each lot received and issues are deducted from the tags, sending bin tags which read zero to the balance-of-stores clerk may prove a valuable check. Figure 33.9 illustrates a very satisfactory form of bin tag. To be effective it must be simple, because of the usual nature of storeroom labor. It must not

be necessary for the storekeeper to keep a running record on bin tags when a balance-of-stores record is kept.

Procedure for ordering material. Goods are ordered by the purchasing department, either upon their own initiative or, in procedures such as we have described, on the requisition of the balance-of-stores clerk. For special unclassified materials requisition will usually be made directly by a department head, although the approval by the balance-of-stores clerk may be made necessary to prevent duplication of items. After receiving the requisition, the purchasing agent makes the purchase and then sends a copy of the purchase order to the balance-of-stores clerk, which is the basis for an entry in the "ordered" column of the balance-of-stores sheet. A copy of the purchase order may be sent to the storekeeper to serve as a basis for identifying and checking material when received. In order that accurate count on incoming goods may be assured, some plants do not enter the amount ordered on the copy which goes to the storekeeper.

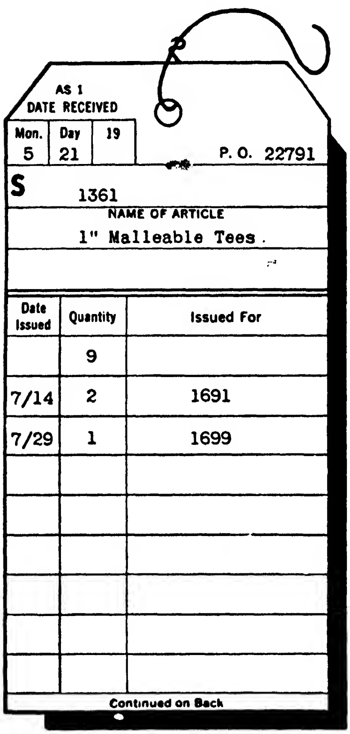


FIG. 33.9. Bin tag.

Receiving stores material from outside sources. All material received should be turned over to the receiving department, which may or may not be under the control of the storekeeper. If articles are delivered directly to the department for which they are ordered, in many instances the receipt will not be recorded, which will lead to difficulty when the invoice is received. The date received, order number, weight, number of packages or bundles, charges whether prepaid or collect, and other necessary information should be recorded, so that a check can readily be made with the invoice.

As soon as a shipment is received, the storekeeper should refer to his copy of the purchase order. He should be responsible for the count and ordering of inspection of all materials received. Theoretically, these procedures should take place before the goods are accepted and receipt is made. However, in order to facilitate receipts by truck, delivery re-

ceipts are often signed as follows: "Received subject to count, weight, and inspection. Signed ——." In this event the contents are carefully checked and inspected at a convenient time. As soon as the material has been checked by the receiving department, a comparison should be made with the copy of the purchase order. Word should be sent to the purchasing department, stating the quantity of material and the general condition in which it was received. Such a report is usually termed a "Notice of Arrival," one copy of which goes to the inspection department as a notice that inspection is needed.[3] In large plants representatives of the inspection department are part of the receiving-room staff.

Upon inspection the inspector should fill out a report, stating that all material is satisfactory or indicating rejections, with causes. One copy of this report should go to the accounting and one to the purchasing department to serve as a guide for the checking and payment of the invoice from the vendor and for the making of claims. Where it is obvious that the material has been damaged or partly lost in transit, notice should be sent to the agent of the carrier to inspect the material. This procedure will facilitate matters if a formal claim is to be made. Receipts of material in excess of the amounts called for on the purchase order should be tagged "Overshipment," with proper identifications, and placed to one side to await final disposition. A rejection tag should be placed on damaged or incorrect shipments. It is essential that *descriptive data, such as purchase order number, incorrect report number, kind of material, and similar information, be stated on it.*

When the inspection report has been received, the storeroom should make out a "Material Received" report,[4] preferably in quadruplicate and signed by the storekeeper. One copy should go to the balance-of-stores clerk who will check against the purchase order and make proper entries on the balance-of-stores sheet. One copy should be retained by the storeroom, and copies should be sent to the purchasing department and the accounting department to serve for checking invoices.

Receiving worked materials. Materials on which a certain number of processes have been performed, or components waiting assembly, must be received and stored until needed. The storeroom will handle these in the same general way as material purchased from vendors, except that no inspection will be needed, and the form on which receipt will be re-

[3] Frequently the inspection department verifies the count claimed by the vendor, thus relieving the storekeeper of counting. This often is the most efficient method since it frequently prevents duplicate handling.

[4] The inspection report is sometimes substituted for this report. The inspection department in this event sends a copy of its report to the storeroom and all the persons to whom the "Material Received" report would go.

ported will ordinarily be a "Worked Materials Received" slip, rather than a "Stores Received" slip.

Stowing materials. After materials for storing have been received and inspected, they may best be placed on a rack or in a space devoted exclusively to materials awaiting storage. There all materials may be tagged with their symbols or bin locations. Some classes of materials should also be arranged in boxes or cans in suitable units for conveyance.

MONTH	DAY	YEAR
10	21	46

STORES ISSUE

CHARGE ORDER NO. 1318

STOREKEEPER:
PLEASE ISSUE THE FOLLOWING

SIGNED G.V.M.

SYMBOL	QUAN.	DRAW. NO. OR DESCRIPTION	WEIGHT	UNIT COST	TOTAL COST
1964	100		17.6		
384	50		4.7		

ENT'D STORES TAG BY	MONTH	DAY	YEAR	STORES ABOVE HAVE BEEN ISSUED	ENT'D INVTY.	ENT'D COST
				STOREKEEPER ____________		

FIG. 33.10. Stores-issue card.

The articles may next be arranged on a truck in logical fashion, in order that they may be unloaded into their respective bins with the minimum of confusion and loss of time. As the specific articles are placed in their respective bins, entries of the date and the amount are made on the bin tag, if there is one.

Issuing materials to the departments. There should be a well-defined rule that no materials can be obtained from any storeroom, warehouse, or yard without the presentation of a formal requisition or issue ticket (see Fig. 33.10) signed by an authorized person. The storeroom should receive the issue ticket from the balance-of-stores clerk in sufficient time to enable it to prepare the material for issuance to the work place in the factory, so that no delay will be encountered between the existing job and the new one.

Some production-control systems call for the department clerk or foreman to write a requisition that is presented directly to the storekeeper. In such systems the storekeeper forwards the requisition after it is filled to the balance-of-stores clerk.

For purposes of accounting and simplicity of storeroom operation, some companies use two different forms for issuing purchased materials and "worked materials" produced within the plant. Other organizations use the same form for both types of materials. Figure 33.11 illustrates an effective type of card to be used in connection with tabulating machines.

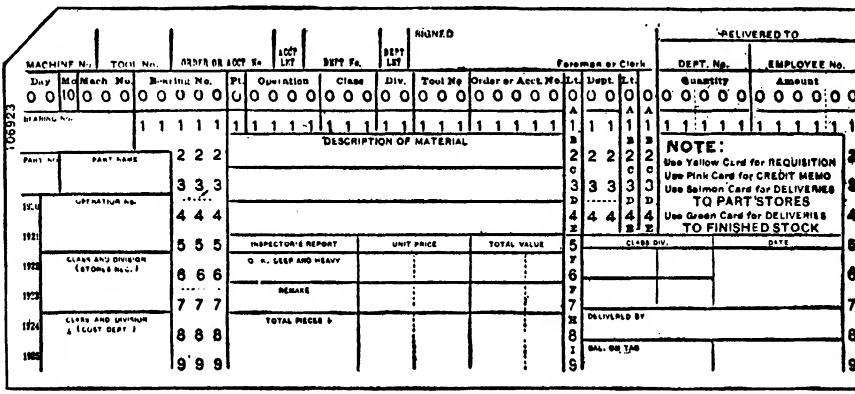


FIG. 33.11. Stores card for use in tabulating machine.

If this system is utilized, all cards may be printed in the same manner, and their various uses designated by varying colors.

A group stores-issue form is used advantageously for parts covering an entire assembly. The use of such a form materially reduces the clerical work of issuing orders. The exact details of the form are determined largely by the individual enterprise, but it usually contains the same information used on a form for one item only. As a matter of fact the same form is often used either for one item or for a group of items. Some manufacturers prefer to have only one item on each stores requisition. The additional clerical work required can be justified only when special use is made of each requisition form.

The "automotive type" of stores issuance makes use of a blanket materials order instead of individual types. Material is sent to the assembly line in accordance with the schedule for assemblies. Irregular items are handled on special requisitions.

In getting out the material, the stores-issue man should, if possible, take enough issue tickets to make up a truck load at a time. Suitable tote boxes (see Fig. 14.13, p. 215) may be placed on the truck to receive

small materials. If the issue tickets are arranged in sequence, the issue man may move from row to row in the storeroom in as direct a line as possible. Immediately upon taking material out of a bin, a deduction should be made on the bin tag, if there is one, and an identification tag, stating the symbol order number and destination in the shop, should be fastened to the tote box or container into which the material has been put.

Occasionally a storeroom handling a number of small items may be operated on a self-service basis similar to that used in grocery stores. Under this system the stock must be arranged on some logical basis. The individual seeking the material gets it himself and checks out through the storekeeper, who verifies the item and the count and collects the requisition. A storeroom may operate in part on a self-service basis and in part on an issue basis. The self-service idea saves a lot of waiting time on the part of workers and stock chasers.[5]

The check or withdrawal slip used by depositors at banks is invaluable for accurately tracing the disposition of funds Critics often say that such a practice in connection with the storeroom is red tape and point out that, if a requisition must be written out to get a screw from the storeroom, the cost of such a procedure is more than the value of the article to be withdrawn. Such an example is fitted only for critical purposes. For practically all articles handled in the storeroom it will be well worth while to maintain a rigid control, and therefore no exception should be made for items which will involve not more than a fraction of one per cent of the issuances. Office supplies and similar articles can be drawn in sufficient quantities at given intervals to overcome small issuances, a check being maintained in the office as they are issued to individuals.

Handling materials returned from the shop. Materials returned from the shop fall into two classes, those which are returned because of necessary overissue in the first instance and those which are returned because some change in the schedule or other complication makes desirable the prior processing of other orders. With proper methods of issuing, usually only the exact quantities of material needed will leave the storeroom, but it is possible at times that overissues must be made. The simplest method of handling such overissues is to have the storekeeper attach a tag marked "Surplus" to the article and retain a copy. If the surplus amount is returned, he destroys all records; but, if the surplus amount is not returned from the shop, he makes out an issue slip and sends it to the balance-of-stores clerk to be properly deducted from the amount on hand and to be charged to the proper accounts.

[5] See *Factory Management and Maintenance,* Vol. 103, No. 3, p. 122.

When materials are returned, the storekeeper makes out a "Stores Credit" and sends it to the balance-of-stores clerk. This slip serves to credit the order to which the materials were charged and goes to the cost-accounting section for that purpose, after the proper entries are made on the balance sheets.

Storeroom personnel. Fixed responsibility is especially necessary in the storeroom. Regulations must be put into force which prohibit all but storeroom employees from entering this department or which permit them to enter only in the presence of the storekeeper or one of his assistants. Only under such conditions will it be possible to make the storekeeper solely responsible for the preservation of material and correct accounting for it. The size and nature of the storeroom organization will vary with the size and the type of business and the kind of material to be handled. Thus it may consist of one man known as the storekeeper, who may give all or only part of his time to the work, or it may consist of a force of men giving full time.

It is sometimes said that such conditions are applicable only to large plants. On first thought it may appear to be poor practice for the small concern which can keep a man only partly busy on storeroom work to place one man in charge of the storeroom. Even for the small plant, however, it is advisable. For instance, it may be quite possible to assign an office employee to the storeroom for a certain length of time each day. By establishing certain hours in the morning and the afternoon, this clerk can take care of all calls for material. At other hours he can attend to his regular work in the office. Some companies have met the situation by placing a workbench in the storeroom at which a worker is engaged while not devoting his time to storeroom work. A manufacturer of centrifugal machines who employs fifty men has combined the functions of storekeeper and shipping clerk in one man.

CHAPTER 34

PRODUCTION CONTROL

Production control defined. Production control is the process of planning production in advance of operations; establishing the exact route of each individual item, part, or assembly; setting starting and finishing dates for each important item, assembly, and the finished product; and releasing the necessary orders as well as initiating the required follow-up to effectuate the smooth functioning of the enterprise. At least one of the items—establishing the route or path of an article through production—may not be controlled by the production-planning and control department, but it must be determined before adequate production control can be achieved. Routing is usually determined in the first instance by the methods department, but the route, once established, is actually controlled or directed by the orders issued by the production-control department.

Production control should be clearly distinguished from the function of actually operating the enterprise. The production-control superintendent is not the operating superintendent. He is the head of an auxiliary staff department that specializes in planning, scheduling, and dispatching as an aid to the operating departments. It is unfortunate that many persons who are not familiar with actual operations confuse industrial management or factory management with production control or production management. In a scientifically run enterprise production control is an important phase of industrial management, but it is only one element. The factory-management group is nearly always the line operating group, to use organizational terminology, whereas the production-control group operates as a staff group.

To set up a special group of persons who concentrate on the planning and clerical phases of control relieves the operating personnel of a multitude of details. The time thus made available enables them to concentrate on their major functions of operating.

The need for production control. Frederick Taylor recognized the need for the specialization of functions. Two of his eight functional foremen were the order-of-work, or route, clerk and the instruction-card clerk. The work of these two clerks has been taken over by the modern production-planning and control department. Taylor was the father of not only modern cost accounting but also of production control.

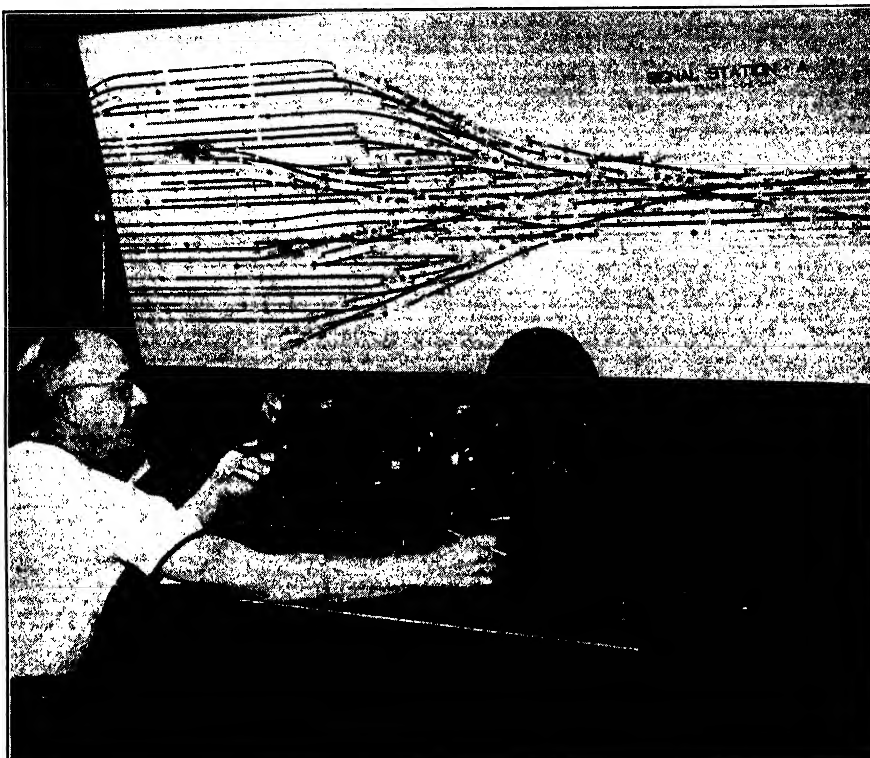
Under any form of organization there must be some control of the productive process. In its simplest form this control consists of taking bills of material or specifications to the shops and giving them to the foremen to use in making up the product. Such bills of material usually originate in the office of the superintendent, and it is to him that the foremen are accustomed to look for advice in manufacture and, roughly, for information concerning which job should be done first. The superintendent's office, sometimes called the factory office, thus becomes the center of information regarding jobs to be done and the general sequence in which they are wanted. Attention is given a particular order while in process only as pressure is applied by the sales department or by a customer demanding prompt shipment. Pressure is then put upon this order by the factory office, whose representative may frequently be seen stalking over the production floors, brandishing the sales telegram, and looking for the order or its component parts. When the order is found, everything else is pushed aside to give it precedence, the requirements for delivery on other orders are forgotten or disregarded, and thus the groundwork is laid for a series of similar telegrams in the near future.

In plants which are operated through the control of the factory office, it is but natural that the orders on which there is pressure are the ones that receive attention. Unfortunately, unless the customer is very patient, or the goods being made for stock are in no real demand, pressure is usually applied sooner or later on nearly every order, and in each case where there is a need for pressure dissatisfaction is likely to be created somewhere along the line. Fortunately plants which operate their production forces in this manner are passing rapidly.

Production control is not confined to the factory. The basic function of routing work and scheduling must be performed in the bank, wholesale house, department store, mail-order establishment, railroad, army, navy, governmental agency, or any other type of organization where many people work together. Figure 34.1 shows the various lines leading into a large depot. The dispatcher exercises control over these lines and, when trains are on time, brings the trains in according to a predetermined schedule. He must also be prepared to adjust his schedule to bring them in when schedules are upset. Exactly the same situation prevails at an airport, or in industry. The aim is to follow an established plan, but adjustments must be made to meet emergencies. It is easier to make infrequent temporary adjustments than to run the enterprise on the basis of one adjustment after another.

Evolution of production control. The creation of a master schedule with shipping dates constituted the beginning of production control. Each department head, with delivery dates in front of him, strove to

push through the items in order to make shipping deadlines. (Shipping dates still remain the controlling data for modern production control.) Orders thus take precedence on the basis of the date when they are wanted. The creation of such a schedule implies the development of a manufacturing-order system, such as is not implied by the lesser control exercised



Courtesy, New York Central Railroad

FIG. 34.1. Dispatcher's control chart for trains entering the Grand Central Station, New York.

through the factory office. These manufacturing orders may or may not correspond to customers' orders but are usually issued to the shop to cover profitable manufacturing quantities. The orders are issued at such time that the work upon them may be completed by the schedule date, but the time of starting work on them is usually left to the foremen of the departments. Besides noting the date wanted on the orders, there is usually some broad division of them into classes which have a particular order of precedence. Division may be made on some such basis as the following:

1. Customers' orders which require special attention to meet the promised date of delivery.
2. Repair orders accompanied by an urgent request for delivery.
3. Customers' orders that will ordinarily come through on time for the promised date of delivery.
4. Routine repair orders.
5. Orders for goods to be placed in stock.

To make a program based largely on delivery dates effective, progress reports and follow-up men are needed. These progress reports give information concerning shortages of parts on various orders, and usually a force of "stock chasers" smooth out difficulties that may imperil the master schedule as soon as they are seen to develop. The causes of shortages or delays may also be investigated, and an attempt made to prevent their recurrence. These stock-chasers or follow-up men may be organized on the basis of the *customer's order* or *related departments.* When organized on the basis of the customer's order, each stock chaser follows an order or a group of orders all the way through the plant. When organized on the basis of related departments, each follow-up man follows all orders in his respective unit or department.

This simple form of production control, using stock chasers to meet delivery dates, endeavors to anticipate delays and eliminate their occurrence, whereas the older method strives only to correct them after they have occurred. As a matter of fact, the very first effort to control orders, other than that of rushing an order when the customer complained, emphasized largely the correction of delays when they occurred rather than their prevention. The simple production-control department, basing its activities largely on releasing delivery dates and using follow-up men to see that these dates are met, has taken the most important step toward complete control of production. Since only the rough outlines of the production program are presented to the shop heads, this department also must frequently act after the need for pressure has been discovered. In other words, drift and check-up are still possible.

In the simple production department a large share of the delays in production is ordinarily due to ineffective operation of staff functions which relate directly to production. Such functions include shop transportation, toolroom operation, maintenance of equipment, and superintendence of raw materials and partly fabricated stores. It therefore frequently becomes logical to place the supervision of several of these functions in the hands of the production department, in order to correlate its activities with each other and with the necessities of the production program.

Definition of terms. *Planning department* is frequently used synonomously with *production-control department* or *production department.* It is possible to have a production-control department with little or no advance planning other than the setting of delivery dates. Planning is the function of looking ahead, anticipating difficulties, and taking steps to remove the causes before they materialize. A complete program of production control starts with planning and makes this planning effective through coordination and follow-up.

Routing includes planning where and by whom work will be done. The *routing* work of a planning department *prescribes the path which work will follow and the necessary sequence of operations,* particularly in building up an assembly product. This work involves such close analysis of facilities that frequently layout is affected. In quantity-production plants, where machines can be set up so that each performs one or several operations in direct sequence, the routing function is directly a part of plant layout. The routing section must have at its disposal all the standards that have been set by job study for the operations and for shop methods. *Scheduling* involves the *planning of the amount of work* to be done and *the time when each element of the work will start,* or *the order of work.* This includes planning for the quantity and rate of output of the plant or departments and also the date or order of starting of each unit of work at each station along the route prescribed. *Dispatching* involves the *meeting of schedules by proper utilization of machines, work places, materials, and workers, as designated by the routing.* The dispatching unit of the planning department thus includes all persons whose duty is to see that orders are issued to the shop, that materials are at the work place, that tools are provided, that job cards are issued, and, in general, that all necessary steps are taken to insure that the schedules will be properly carried out. In determining when and where work is to be done, the planning department performs management functions which have been given definite technical names, the use of which will clarify any description of the work of the department and eliminate confusion of terminology.

The functions of a complete production-planning and control department. The comprehensive production-planning and control department receives orders from the sales department or operates according to a master budget; it takes all the steps necessary to see that the product is shipped according to the promised dates. Such functioning implies the centralization of control and responsibility for coordination over the following four elements of the production process:

1. The manufacturing orders.
2. The material for these orders.

3. The productive equipment, including machinery, tools, and work places to be used.
4. The workers, in so far as priority of work is concerned.

The production-control department in some instances has control of the departments handling material and in others merely issues the orders on another department that handles the material. The production-control department seldom actually has control of the equipment; it usually issues orders on the maintenance department to have the equipment ready. In a few cases it establishes priorities for the work of the maintenance department. Seldom does the production-control department have any direct control over the workers, but it schedules work to the machines, leaving the assignment of a particular worker to the discretion of the foreman.

Production planning takes the four elements which have been listed, works with them, each in relation to the other, and operates through them in such a manner that the product is turned out in the time and by the methods that are desired. The orders are the authorization for the performance of the work, and writing them carries with it an implication of coordination with the sales and financial aspects of the business. The material comprises everything upon which work is to be done, whether it be raw stores, worked material, or components which are the product of another plant. The productive equipment comprises all machines, tools, and work places within the factory which are utilized for manufacturing purposes, and its control implies its utilization for such productive work as may be deemed best at a given time. All these factors are coordinated by the planning department, so that a series of operations, based on needs of the manufacturing orders, upon capacities of equipment and workmen, and upon condition of material, are developed. These operations are then laid out, supervised, and correlated in such a manner that work will proceed through the plant in the smoothest and most orderly fashion.

No work is performed by the well-organized planning department which should not be performed by someone under any type of organizational setup. The centralization of all planning work insures not only that it will be done, but also that it will be done by qualified persons in a way which will be of most benefit to all within the organization. The planning department provides an opportunity for the accumulation of centralized knowledge and a utilization of this knowledge.

To establish a planning department involves taking over from line members of the organization control over (1) when work is to be done, and, within limits, (2) where work is to be done. The extent of control

that this department may exercise over these phases of the plant's activity must necessarily vary with the plant and the product.

Prerequisites of successful production control. Partial production control can be inaugurated with relatively little standardization of procedures, processes, materials, and product. A high degree of central control of production planning, however, is predicated upon the existence of the following organizational policies, reliable information concerning productive capacities and requirements and standard conditions:

1. Organization.

1.1. Recognition by management of the need for production planning and willingness to delegate authority with the responsibility.

1.2. Recognition by the supervisors whose work schedules are being centrally determined that this is merely an extension of functional specialization which makes possible their devoting more of their time to those activities for which they are best qualified. This attitude produces cooperative effort.

2. Reliable information concerning requirements and productive capacities.

2.1. Knowledge of products required to be produced. A master schedule of production required from the sales department is highly desirable. When production is to customer's order, the schedule may be built by the planning department from the individual orders.

2.2. Detailed information about the number and types of each production machine and processing unit, together with the feeds, speeds, and productive capacities. In addition to the capacities, it is necessary to know the available time not scheduled in the case of intermittent manufacture.

2.3. Detailed information concerning the manufacturing time required and the sequence of operations for each part going into the finished product and for the finished product as a whole.

2.4. Detailed information concerning material requirements, amount on hand, amount required, length of time to get delivery for items purchased, quantities used per unit of production.

2.5. Detailed information concerning the available labor in the shop and the productive capacities of the men.

2.6. Complete information concerning the manufacturing operations for each part, the proper tools, jigs, and fixtures for each part, and their availability.

3. Standardization.

3.1. Materials purchased and fabricated.

3.2. Operations on all parts as far as design permits.

3.3. Tools and equipment as far as practical.

3.4. Procedures of operations and organizational setup, including delegation of authority and fixed responsibility.

3.5. Production standards for employees and method of remuneration for employees.

3.6. Quality requirements and adequate inspection to guarantee quality maintenance.

3.7. Reports on production performance in comparison with scheduled production.

The foregoing prerequisites may not all be fully realized in a particular situation, but the more nearly they are realized the greater the chance for successful operation of a centrally controlled planning department.

The organization of the production-planning and control department. The organizational philosophy of top management and the standing of the person in charge of production planning and control largely dictate the position of the department. The type of manufacturing and the size of the plant are also influential. In one large company all internal and external transportation, material handling and storage, stock records, and tool cribs are under the charge of the production-planning and control department. In turn the department answers to the purchasing agent, who is a vice-president. This is an unusual arrangement, but it works successfully. If this same vice-president had come up through production control, purchasing, in all probability, would have been a division of production control.

All phases of management development influence the operation of production-planning work. The method of organization, the development of standards, the extent of job study, the presence or absence of an administrative budget procedure are all important. A good illustration of the effect of the type of management on the outlines of the planning department is found in the extent of the job studies that have been made. Job study is by no means an essential prerequisite to the operation of planning control, but the minuteness with which planning may be carried on will be dependent directly on the extent of job-study data. Without job study large allowances must be made in planning work.

Planning problems in clothing and metal-cutting manufacture or in paper and standard textile manufacture are essentially similar. But planning for production in a flour mill has few similarities to such planning in a lock factory. In continuous industries manufacturing standard products on a quantity basis the scope of the production or planning department is far different from what it is in the jobbing shop. This subject will be discussed in detail in Chapter 39. It is sufficient to indicate here that, by giving adequate consideration to plant layout, the problems of routing and dispatching between operations have been eliminated to a great extent. It is to the schedules that most planning attention must be given in such plants.

In assembly industries manufacturing diverse products the most involved planning-department organization is found.

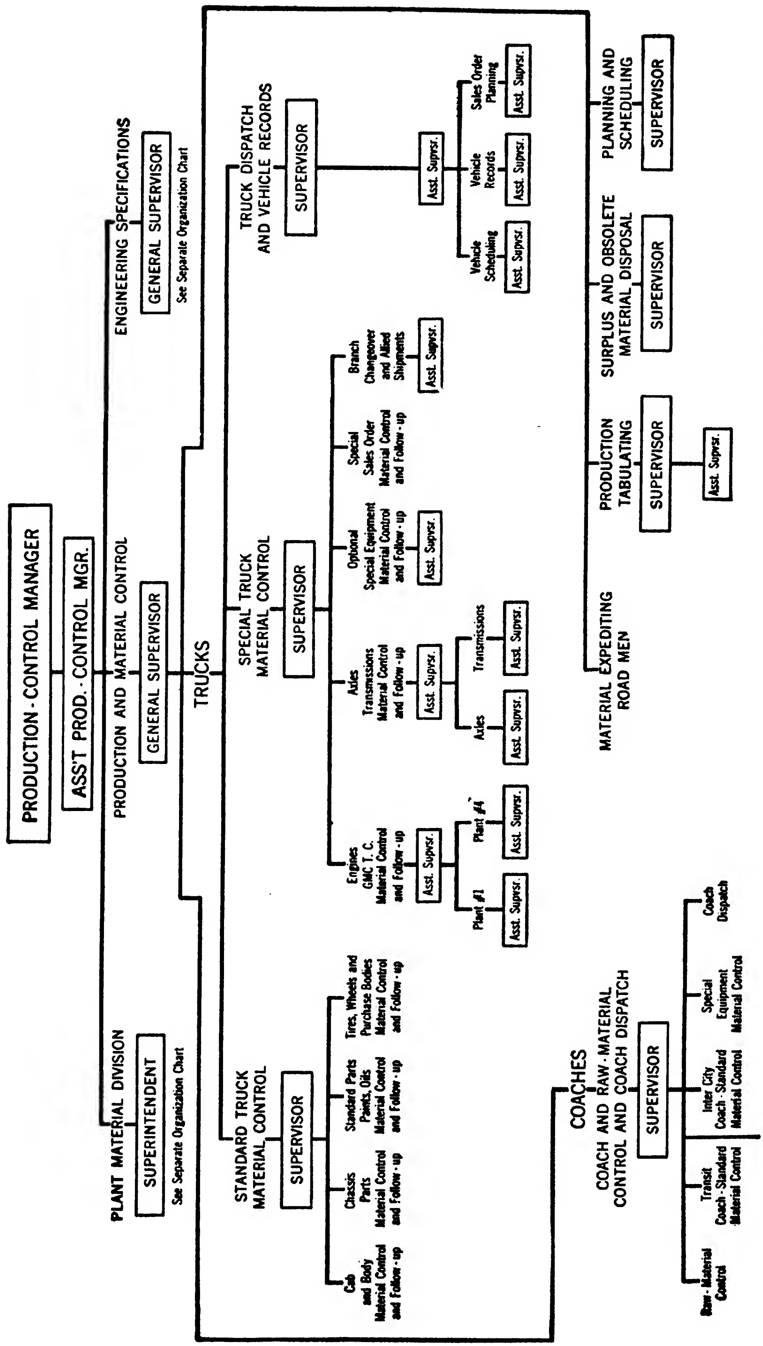
From a purely organizational setup it would appear that production planning and control, inspection, manufacturing, and plant engineering might well be coordinate departments answering to the general factory manager. This arrangement would, of course, imply that each of these

divisional heads would be thoroughly qualified to carry the load of his division. Too many production-control men have had little or no operating experience; hence their approach is largely clerical. Under these circumstances it is but natural that the position of the superintendent of production planning and control is not on the same level as that of the superintendent in charge of manufacturing. Neither would such a man be likely to be placed in charge of receiving, shipping, material storage and handling, or transportation.

Figure 34.2 illustrates the organization of a production-planning and control division in a large manufacturing plant. The man in charge of this division has a rich background of experience and is thoroughly qualified to handle the responsibilities of centralized planning and control.

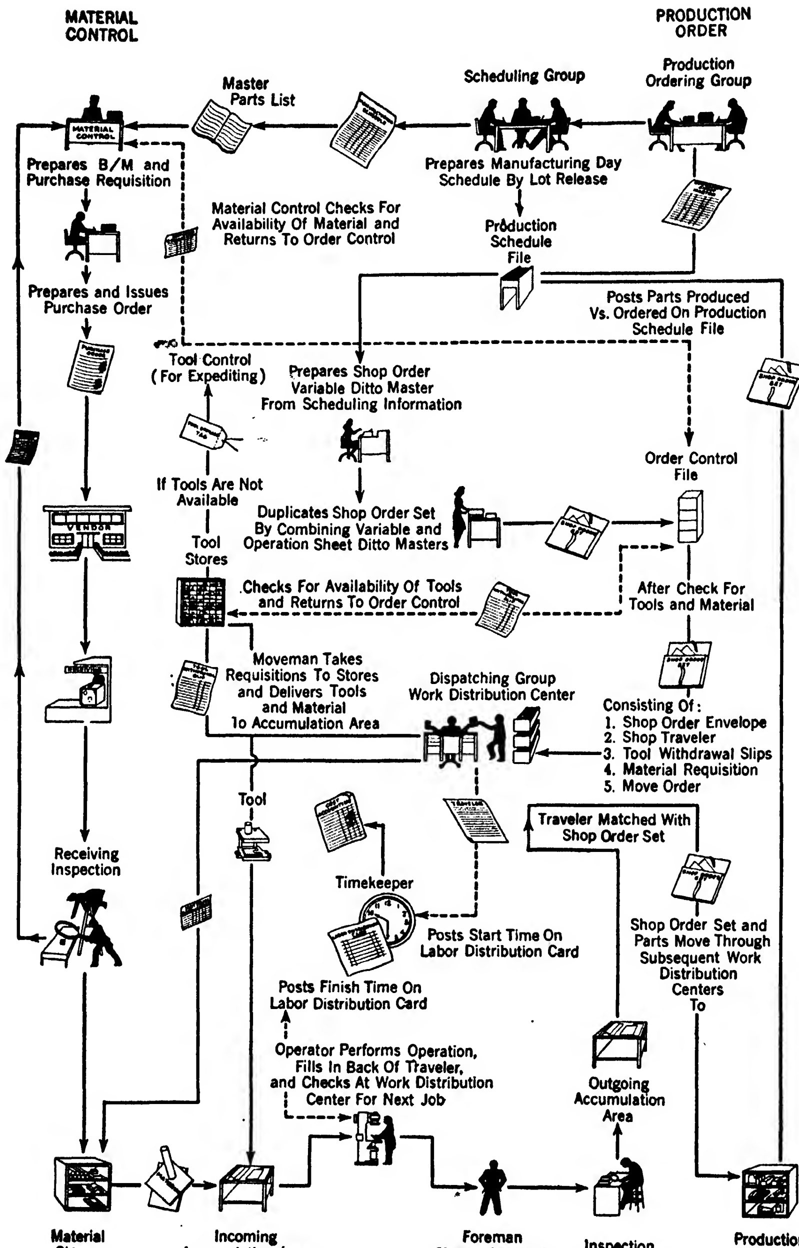
Regardless of the actual lines of authority, the planning department must work in close coöperation with the following departments: cost, purchasing, standards and methods, plant layout, tool, factory maintenance, inspection, stores, shop transportation, finished stock, sales, and shipping. Figure 34.3 illustrates the relationship of production control to materials control in a large airplane factory. Many of the data used by the cost department are collected by the planning department. Purchases are often made on requisitions from the balance-of-stores ledger clerk. Planning is accomplished through the use of data supplied by the standards and methods department. Plant layout largely determines the routing and sequence of operations, especially in line production. Shop transportation of materials and product is usually done on order from the planning department. The availability of finished stock and the inventory of finished stock are directly tied in with the plant's schedule. Customers' orders originate with the sales department but must be scheduled by the planning department unless filled from finished stock. The sales department gets its promises for delivery dates from the planning department, which relies upon the tool department for tools used in production and cannot schedule actual operations until the tools are available. The keeping of scheduled promises is intimately associated with the maintenance of equipment in running order. Inspection in many instances is an operation in the production sequence and must be scheduled just as other operations.

Centralized versus decentralized control. In small concerns centralization is without question the desirable ideal, but in large factories decentralized control is usually found. A central department correlates the activities of the various individual planning units, which are usually located in each of the producing departments of the plant. Under decentralized control the over-all department schedule is determined by



Courtesy, General Motors Truck and Coach Division, Pontiac

Fig. 34.2. Chart showing the production-control division of the General Motors Truck and Coach Division.



Courtesy, Curtiss-Wright Corporation

FIG. 34.3. Chart showing the relationship of production control to material control in an airplane plant.

the central planning department, but the details are worked out by the individual planning unit within the department (when there is one) or by the foreman in the absence of a representative of the planning department.

The planning clerk in each department may report either directly to the foreman or to the planning department. In either case he will report to the central planning department functionally. By this system the central planning department retains essential control of production from raw materials to finished stock, and at the same time in large plants its schedules and plans become more flexible and more readily adjusted to day-by-day and hour-by-hour happenings in the shop. This type of planning control merely provides for the moving of some of the detail-planning work to the departments, without in any way reducing the correlation of major activities of the plant. The central planning department still controls the schedules and the dispatching [1] between departments. The planning supervisor in each department controls dispatching within the department. Routing may be carried on in the place which seems most desirable under given plant conditions.

Decentralization of planning control brings with it relief from certain dangers against which centralized control constantly must guard. It is easy to get out of touch with departmental or plant conditions. It is easy to lose the cooperation of the foremen and subforemen, upon which depends, in a large measure, the success of planning work. If these men feel that orders are being sent to them for mere execution, and that the management of the plant is going around them rather than through them, the planning forces are likely to lose their all-essential support. Although with central control the foremen should be in and out of the planning department all day long, decentralized control enforces the aid of foremen in planning. Thus, not only are the data collected by the experts of the planning department available, but also the mass of technical information concerning production which has been accumulated by the foremen through long years of direct contact with the job can be utilized. Decentralized control should not involve supervision of clerical detail by the foreman in sufficient amount to affect his capacity to produce. In modern mass production there is a definite trend toward decentralized planning control.

[1] Special move orders need not always be issued by the central planning department unless it is from a central partly fabricated storeroom; even then these orders may be quantity orders rather than orders for each load. Dispatching may be carried on by the department planning unit as soon as the work is finished in the given department. In the "flow type" of manufacture many planning details are minimized.

The cost of production planning and control. The costs incurred in production control are frequently urged as an argument for the old system of having each foreman do his own planning and scheduling. Production control does involve clerical labor. That it does not involve unnecessary expense is proved by the experiences of those who have installed elaborate planning departments and have had them operating for some years. Although clerical overhead may be increased, shop overhead is usually decreased. It is not necessary that the small plant have a different person perform each function that has been or will be described. On the other hand, in large establishments many workers are needed to handle the detail of planning. No fixed number of persons or fixed arrangement of functions is possible in organizing a planning department.

Production planning is the answer to greater production on the same investment without unduly speeding up workers. One plant during World War II was called upon to expand production of its regular product 400 per cent. Normally the work in process was about $70,000. In an effort to meet the new demands the work-in-process inventory was increased by $500,000, yet the desired production was not forthcoming. The foremen were overworked with the burdens of training new men, scheduling their production, and trying to develop better methods. The able assistant to the foreman of the largest department was placed in charge of a complete production-control and planning department, which also included a methods department. In less than three months production schedules were being met, quality rose, and the work-in-process inventory was back to normal for the volume of production. The foremen were freed of clerical details so that they could concentrate on matters for which their skills were most needed.

Effective planning always means effective control of detail. It is this detail, properly coordinated, which makes not only for an even flow of production but also for accurate costing.

In summary the advantages of production control may be said to include the following points:

1. Better service to customers, in that promised delivery dates are kept.
2. Fewer rush orders in the plant and less overtime than in the same industry without adequate production-planning control.
3. Lower inventory of work in process.
4. Less finished stock required to give the same service to customers.
5. Better control of raw-material inventory, which contributes to more effective purchasing.
6. More effective use of equipment.
7. Less loss of time by workers waiting for materials, with improved plant morale as a by-product.

CHAPTER 35

PRODUCTION CONTROL—ROUTING

Routing production. The first phase of routing is performed by the engineering or the methods department. The technical aspect of routing includes the establishment of the particular operations to be performed and the sequence of these operations with the possible addition of the particular machines to be used on the respective operations. From the standpoint of the production-control department routing includes *the planning of where and by whom work shall be done, the determination of the path that work shall follow, and the necessary sequence of operations;* it forms a groundwork for most of the scheduling and dispatching functions of a planning department. Only the development of the master schedule and the issuance of manufacturing orders precede it. The scope of routing may well be subdivided as follows:

1. The analysis of the finished article from the manufacturing standpoint, including the determination of components if it is an assembly product. Such analysis must indicate the materials or parts needed, whether they are to be themselves manufactured for an order, or whether they are to be found in stores, either as raw or worked materials, or whether they will have to be purchased, and the quantity of materials needed for each unit and for the entire order. Much of this work may have been done by the engineering or design department in drawing up the specifications for the product, but these must be studied and checked from the production standpoint.
2. The fixing of the sequence of completion in manufacture that one part, or piece of material, bears to another, in order that all may be brought together as needed in the process of manufacture (see Fig. 39.1).
3. The determination of the operations which must be performed at each stage of manufacture, and the place where these shall be performed. This implies a division into such operations as will utilize to the best advantage both the skilled and the unskilled members of the factory's production force and all equipment. It is here that the results of job studies are of great importance. The actual selection of machines and workmen after operations have been determined is the portion of the routing function that is most frequently performed decentrally.
4. The division of total quantities required into proper manufacturing lots or batches.[1] This must be done with due reference to length of operations, space occupied by the material while moving through the shop, and the requirements of the master schedule.[2]

[1] See p. 524.

[2] See Fig. 39.1 for a combination schedule and route chart.

Practically all the work of routing concerns production control in advance of actual production. The routing function most clearly distinguishes the work of the planning department from that of the simple production department. The automobile is a product in the manufacture of which the various phases of production control, routing, scheduling, and dispatching have been highly developed. The finished car is essentially an assembly of various parts manufactured and brought together as subassemblies. Similarly, in manufacturing an assembly product, such as a clock, there are a number of small components, each of which must be provided in adequate amount before any attempt to make either subassemblies or the finished product. The raw material comprising each of these components must be put through a number of manufacturing operations before being available for subassemblies, and decision must be made concerning the most economical operations and machines for the manufacture of each component with due consideration for other current demands on the workmen and equipment of the shop.

Some manufacturing is so extremely simple and the product is so uniform that only a very simple routing mechanism, if any, is required after the plant once begins operations. For instance, a flour mill which operates day after day and year after year on the same kind of raw material, turning it into the same type of finished product, will have but little need for an elaborate system of routing. However, even with a standard product. several types are usually manufactured; some components or materials take longer to work up than others, and thus numerous problems of routing and machine utilization arise.

Plant layout, routing, and symbols used for identification. One of the outstanding trends during the past ten years in manufacturing and production-planning control has been the increased use of layout by product, which facilitates inventory and production control. This type of production control is known as "flow control." The essential features of this type of production control are starting the product on a line and having all needed parts available as the assembly proceeds. Figure 39.1 illustrates a series of interrelated line controls. The plant layout[3] determines to a large extent the route a given part, subassembly, or product will take. Line production or layout by product, as has been pointed out, greatly simplifies production control.

The second management step closely associated with routing is identification of materials and operations. Routing and identification should be interdependent. A skeleton identification classification for stores, worked materials, and finished stock is of great assistance in developing

[3] See Fig. 12.10, p. 175.

A. B. DICK COMPANY
CHICAGO

PARTS LIST · MATERIAL REQUIREMENTS

DATE ORIGINAL ISSUE May 27,1946 NO. 1
APPROVED A. E. Newman
CHIEF ENGINEER
SHEET ___ OF ___

LEGEND
M=MAKE F=BUY FIN. COMPLETE S=BUY SEMI-FIN.
D=DICK V=VENDOR C=CUSTOMER

MODEL ASSEMBLY NO. 49728 NAME OF ASSEMBLY Steering Head

LINE	A. B. Dick Part No.	Customer's Part No.	PART NAME	First Subassembly	Quan. Per Unit	Make Buy M F S	Mat. Furn. by D V C	MATERIAL DESCRIPTION: MATERIAL / SIZE / SHAPE	QUAN. PER 100 PCS. Unit	QUAN. PER 100 PCS. Quan.	Spec. No.	Size, Shape, Code No.	C. M. P. Code No.	LINE
1														1
2														2
3	24945	1590525	Arm	24953A1	1	M	D	Stainless Steel Type 304,0.0126 ± 0.001	lbs.	0.980	94 05	28214	2531	3
4														4
5														5
6	24946	1590526	Boss	24947A	1	M	D	Aluminum Alloy 52S, 0.0508 ± 0.0025	lbs.	0.643	11 03	26367	4311	6
7														7
8														8
9	24947	1590527	Arm	24947A	1	M	D	Aluminum Alloy 52S, 0.0508 ± 0.0025	lbs.	1.819	11 03	26368	4311	9
10														10
11														11
12	24948	1590528	Eccentric	24947A	1	F	V	Aluminum Alloy 17ST, 0.3125 ± 0.0015			11 01		4121	12
13														13
14														14
15	24949	1590530	Operating Pin	24947A	1	M	D	Aluminum Alloy 17ST, 0.125 ± 0.0015	lbs.	0.062	11 01	17032	4121	15
16														16
17														17
18	24950	1590532	Pivot Bearing	24953A2	1	M	D	Stainless Steel Type 416, 0.156 ± 0.001	lbs.	0.325	96 01	17042	2501	18
19														19
20														20
21	24951	1590534	Pivot Bushing (Short)	24953A1	1	M	D	Stainless Steel Type 416, 0.156 ± 0.001	lbs.	0.170	96 01	17042	2501	21
22														22
23														23
24	24952	1590535	Reflector End Bracket	24953A1	2	M	D	Brass 1/2 Hard 0.025 ± 0.0017	lbs.	1.230	21 03	28286	2501	24
25														25
26														26
27	24953	1590536	Reflector	24953A1	1	F	V	Ground Plate Glass						27
28														28
29														29
30	24954	1590537	Pivot Bushing (Long)	24953A1	1	M	D	Stainless Steel Type 416, 0.187 ± 0.001 Square	lbs.	0.695	96 01	17497	2501	30
31														31
32														32
33	24955	1590542	Cover Plate	24953A2	1	M	D	0.0253 – 0.002 Aluminum Alloy 17ST or 24ST opt.	lbs.	10.700	11 01	28287	4311	33
34														34
35														35
36	24956	1590543	Reflector Support Bracket	24941A	1	S	D	Aluminum Alloy Die Casting AC 13 or AC 15	lbs.		10 01		4207	36
37														37
38														38
39	24957	1592814	Fillister Head Screw	24941A	3	F	V	Stainless Steel Type 416 or 410			96 01		2501	39
40														40
41														41
42	24958	1590918	Nut	24953A2	1	F	V	Stainless Steel Type 303			94 03		2501	42
43														43
44														44
45	24959	1591305	Pin		3	F	V	Stainless Steel Type 303, 0.110 – 0.0003			94 03		2501	45
46														46
47				24941A	2									47
48														48
49				24505A2	1									49
50														50

Courtesy, A. B. Dick Company

FIG. 35.1. Bill of materials.

routing work. As the route of a product is determined, components are analyzed, and the operations are fixed, the proper identifications are assigned and recorded on the bill of materials and operation sheet. Routing will be greatly facilitated if material symbols [4] and operation symbols are so devised that they may be used directly in the work of routing and included in the routing instructions which are issued by the planning department.

Routing from the bill of materials. The bill of materials and the specifications are provided by the engineering or methods departments. When they are received for a special order or for a product to be produced for stock, the work of the production-control department begins. As indicated in Figs. 35.1 and 35.2, a list of the components of the product, together with specifications of the materials from which they are to be made, manufacturing tolerances for machined parts, and frequently a list of the operations to be performed on each component are generally provided. The last item may be left entirely to the production forces; but, if it is, close contact must be maintained between the two departments to insure that designs do not involve unnecessary manufacturing complications.

The complete bill of materials and the specifications constitute a master list from which all production-control data are derived. At times the production-control department may have to compile its own lists from those provided by the design department, especially when the work of the various members of the department is functionalized.

Additional data needed by the production-control department. Not only must complete specifications for the finished material be on hand before routing is attempted, but also much additional information must be available. On operations which have been previously performed, job-study data should be available for reference, and on new operations job studies must be made and the results reported to the planning department. If there is not time for job studies on new operations, then the advice of the job-study man or the foreman must be secured concerning the routing of the work. He will be able to give much valuable advice from his knowledge of equipment capacities. It must not be inferred that the route man may be ignorant of the shop equipment. If routing is to succeed, the route man should be the person in the whole shop organization who knows most concerning manufacturing method.

If routing to particular machines is to be attempted, some record of available machine capacities must be at hand. This may take the form

[4] See Chapter 31 and Appendix B for a detailed discussion of the use of classification and identification symbols.

ASSEMBLY PARTS LIST

LEADER MANUFACTURING COMPANY

ASSEMBLY NAME Mimeograph 90 Duplicator DATE 8/25/46

ASSEMBLY NO. 15001-A2 ISSUE NO. 3 SHEET 14 OF 20

Quantity Required							Part No.	Description	Source
		1					15364	Feed tube guide channel	
		1					15351-A2	Sheet feed raising lever assembled	
			1				3208	Roll stop truck	
			1				3209	Roll stop truck rivet	
			1				15351-A1	Sheet feed raising lever assembled	
				1			15349	Sheet feed raising lever spacer	
				1			15351	Sheet feed raising lever	
				1			15352	Sheet feed raising lever hub	
				1			15385	Synchronizing pin for sheet free arm	
				1			21764	Table tripping sector spring pin	
	1						15326A	Feed driving eccentric assembled	
		2					177J	Flat-head screw #10-32×3/8	
		1					6936	Roll-locking lever operating arm	
		1					15302	Eccentric ring	
		1					15303A	Feed driving eccentric assembly	
			1				15301	Feed raising arm cam	
			1				15303	Feed driving eccentric	
			2				177C	Flat-head screw #10-32×3/8	
			1				15395	Eccentric clamp screw	
		1					15365A	Feed bell crank assembled	
			1				15365	Feed bell crank	
			1				15366	Bell crank tube push pin	
			1				15381	Feed bell crank rod hub	
			1				15382	Feed bell crank pivot rod	

CHANGED BY													
DATE													

Courtesy, A. B. Dick Company

FIG. 35.2. Route sheet combined with an assembly parts list. Note the vertical columns at the left. The numbers in each column indicate the number of each part used, and counting columns from the left to right indicates the order in which parts and subassemblies go together.

of a rough record of the relative amount of work that is being given to each machine, or it may take the form of the more complicated Gantt-chart portrayal of machine load.[5] Such a record will prevent continual preference for one particular machine or machines if alternate choices can be made and will enforce consideration of the utilization of all the shop equipment of the shop on those in charge of routing. This record quickly indicates the approximate amount of work that the routing has at any time assigned to each machine or class of machine in the shop. In order to promote flexibility of dispatching, alternate machines should be indicated in the routing whenever possible, but any cost advantage in the use of one machine over another should be shown by designating clearly the preferred machine. Frequently, because of the nature of the operation, no preference can be shown.

Route sheets. The path that a particular item is to follow through production may be recorded graphically or in tabular form on what is known as a route sheet (see Figs. 35.2, 35.3, and 35.4). These are prepared in advance of need and filed in a *route file.* Route sheets list fully the materials that are necessary for a given operation, the complete list of operations in sequence, and the machines on which they are to be performed. In addition, for dispatching purposes, the standard time for each operation may be given, and check spaces are provided to record the progress of the order through the shop.[6] Different types of route sheets are usually needed for components and for assemblies because of the different natures of the operations involved.

Route sheets serve two purposes: (1) They indicate, for scheduling and dispatching purposes, the necessary operations to be performed, and the place where they are to be performed; when accompanying material or released to the departments, they constitute the authority to manufacture. (2) Through the check columns they provide a progress report which gives at any time the status of any component, assembly, or order that is in manufacture. Furthermore, since only one lot of material is governed by a single route sheet, the work is divided up definitely into the lots or batches which have been determined upon as desirable from a manufacturing standpoint.[7]

So-called "master departmental or divisional route sheets" are frequently made out in the central planning office and given to the decen-

[5] See Fig. 36.1, p. 493.

[6] It should be clearly borne in mind that these forms are purely illustrative. Each industry's needs and the requirements of each department will govern the exact form and data to be included. Production-control systems, like other management techniques, should be adjusted to the needs of the individual enterprise.

[7] This statement, of course, implies that there is sufficient volume to justify the desired economic lot size.

tralized planning office as a guide. This route sheet shows the sequence of operations and types of machines, but not the exact machine unless there is only one of the desired type. Assembly route sheets must show clearly the sequence of assembly operations, particularly whether the operation may be performed independently or simultaneously or must be performed in sequence after another assembly operation because it depends on the product of the latter for a portion of its material. On an assembly route sheet it is necessary to show what additional material is needed for the performance of each operation and should be supplied at various points in the assembly process.

Routing two or more items together. Because of particular manufacturing conditions it may be desirable to have two batches of material routed together for a certain distance through the course of manufacture and then split. Or it may be desirable to bring together two or more batches of material at given points in the manufacturing process, although in the main they will follow separate courses. Such conditions usually call for combination routing, which provides for the routing of the various batches so that the relation of one to the other will be clearly evident. Combination routing is provided for several jobs in production which may use the same setup on any machine. In order to save time and setup cost, these jobs are routed in combination.

Route files. When the necessary information concerning materials, operation (Fig. 35.3) to be performed, assembly order, and quantities to be produced is available, one of the next steps is the preparation of the papers and instructions for the factory. The route file, which includes all tickets needed for planning and dispatching work during the course of the order in the shop, such as time and job tickets, requisitions for worked materials and stores, operation orders, inspection tickets, and move tickets or tags, must be made ready. These tickets (Fig. 35.5), which are usually prepared in the main by some duplicating process (Fig. 35.6), are suitably taken care of by some filing scheme until they are needed for dispatching to the plant. Sometimes they are all placed in pockets in a specially constructed file, which contains all route sheets and papers pertaining to one manufacturing order. Thus in the route file information can be found concerning the path that the order is to take through production, plus all necessary forms which will be utilized in dispatching, working, paying for labor, or recording costs for the order, plus the necessary columns on the route sheet to record accurately the progress of the order. To these often will be added tool lists to be sent to the toolroom as given operations are called for in the process of dispatching, and instruction cards to be issued to the workmen as the operations are to be performed. Route sheets are at times arranged in the

form of a visible index, so that they may be easily referred to by the dispatcher; in this case the necessary forms are filed close by in boxes or tub desks. The use and issuance of the various papers which are pre-

ROUTING S14

Issue 8, 10-12-46 Type: Single-Duty Rings

Department Number	*Department*	*Operation*
02	Rough Stores	1. Receive Rings from Foundry and Issue to Disc Grind
03D	Disc Grind	2. Disc Grind
03P	Preparatory Disc Grind	3. Preparatory Disc Grind
03F	Finish Grind	4. Finish Grind
03W	Wash	5. Wash and Dry
06-1	Width Inspection	6. Width Gage, 100%
17	Turn	7. Turn and Cut
18	Bore	8. Bore
30-1	Semifinished Visual Inspection	9. Visual Inspection 100% (Only pans with Hard-Ring Tickets)
21	Groove	10. Groove
		11. Burr
		12. Blow and Align Gaps
22	Finish Turn	13. Finish Turn
24	Size	14. Size
29-4	Wall and Tension	15. Width Gage Percentage or 100%
29-2		16. Wall Gage Percentage or 100%
29-3		17 Weigh Tension Percentage or 100%
29-6		18. Light Test Percentage or 100% (100% at Miscellaneous Inspection)
30	Finished Visual Inspection	19. Final Visual Inspection, 100%
28-1	Gap Inspection	20. Gap Gage Percentage or 100%
36	Oil and Roll	21. Oil and Roll

This issue supersedes Issue 7, 8-13-46.

Reason for reissue:

Process engineering.

Courtesy, The Perfect Circle Company, Hagerstown, Indiana

FIG. 35.3. Route and operation-sequence sheet for a piston ring.

pared will be described in Chapter 37 under the order of work and dispatching procedure.

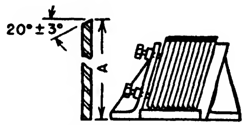
Special equipment has been developed to be used in connection with the modern punch-card tabulating machinery which greatly modifies and simplifies the preparation of all the orders and instructions used in production planning and control (see Fig. 35.7). Master route cards, in-

Equipment and Tool Name		*Part No.*	
		Tool No.	*Req'd.*
Cincinnati Milling Machine		STD	1
Yale Skid		STD	2
Clamps—Angle (set)—3		BT-2045	1
Cutter—Spiral Split 2½ × 6 × 14¾ (Use scrap cutters if available)		BT-2248	1
Block—Riser		BT-2059	2
Arbor—2½″ × 42″		BT-2220	1
Plate—Stop		BT-2221	1
Crow Bar—Spec.		BT-2222	1
Coolant—Van Straaton #523		STD	—
Gage—Plate Width	(512)	SPG-20532	1
"	(528)	SPG-31000	1
"	(814)	SPG-20531	1
"	(836)	SPG-20531	1
Punch—Forked		BT-2292	1
Wrench—Double end (1⅛ × 1)		STD	1
Hammer—8-lb. sledge—dbl.-face		STD	1
Bar—Spec. pry		BT-2225	1
Wrench—dbl.-end (1¼ × 1)		STD	1
Wrench—1¼ socket, right angle handle		STD	1
Brush—Chip		STD	1
Pan—Chip		BT-2250	1
Block—Wood (Steel reinforced to protect machine)		BT-2224	1
Cloth—Wiping		STD	—
Budgit Hoist		STD	1
Spacers—2½″ dia. (set)		BT-4659	1

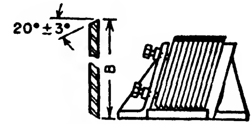
Chg. Let.	Alteration Made	Date	Chg. by	Chk. by	Used on Model No.	Eng. Chg.
					836-17C2 836-2C2 814-4&6C3 528-1C2 512-1&2C1.5	

Design	*No. of Plates*	"A"	*Tol.*	"B"	*Tol.*
836	10	14.375″	+.000 −.070	14.250″	+.000 −.070
814	10				
528	10	12.407″		12.343″	
512	11	10.905″		10.812″	

Fig. 35.4. Operation sheet. Note that the instructions are in sufficient detail



First Milling Cut



Second Milling Cut

Operation Procedure

1. Cutter is mounted on arbor to mill conventional. The cut begins at stencilled end and progresses toward the tip end of plates.
2. Wipe fixture and check to see that it is free of chips and dirt.
3. Position end plate on fixture and secure.
4. Remove plates from skid and load on bed plate one at a time until all plates are loaded; set plates at proper angle (see chart.)
5. Tighten set screws in plate holding fixture.
6. Hammer top edges for proper seating of plates.
7. Retighten set screws securely and adjust shield.
8. Start cutter and turn on coolant. Be sure that a steady flow is directed on the cutter while milling.
9. Run table at fast speed until stencilled end of plates is within 3″ of cutter; then set machine to specified automatic feed.
10. Mill plates (see chart for feeds and speeds).
11. Upon completion of cut, reverse feed and run table at fast speed to original loading position.
12. Turn off coolant and stop cutter.
13. Clean out chips.
14. Remove shield and loosen bolts on holding fixture.
15. Remove end fixture.
16. Loosen plates with bar and remove to skid.
17. Clean bed plate and fixture.
18. Position end plate on fixture and secure.
19. Remove plates from skid and load in bed plate one at a time, milled edge down. Set plates at proper angle.
20. Follow Procedures 5, 6, 7, 8, 9, and 10.
21. After 4″ of the plates have been milled, operator is to back plates away from cutter and have inspector check width of plates with gage. Make necessary adjustments.
22. Follow Procedures 8, 10, 11, 12, aud 13.
23. Upon completion of entire cut, have inspector check width of plates at center and both ends.
24. Follow Procedures 14 and 15.
25. Loosen plates with bar and remove to skid.

Cutter speed, r.p.m.:	40
Feed in per. min.:	4

Note: Dimensions = 0.010 unless otherwise specified.

Shadow and Tool Sheet

Operation:		Mill Plate Edges			Part Name Camber	
Met'ds Eng.	L.A.H.	11-29-44	Prod. Eng.	Date	Dept. No.	
Proc. Chk.	A.A.W.	11-17-44	Met'lrgy Chk.	Date	Mat'l Spec. S.A.E. 4330	
Proc. by	H.S.C.	10-28-44	Insp. Chk.	Date		
Drawn by	S.T.	10-28-44	Prod. Chk.	Date	Sheet No.	1 of 1
Curtiss-Wright Corp. Propeller Division				Plant Beaver	Oper. No.	880

Courtesy, Louis A. Hradesky, Methods Engineer, Curtiss-Wright Corporation, Propeller Division

so that a beginner can perform the operations with a minimum of instruction.

PROCESS SHEET · SPECIFICATIONS AND ROUTING

SHEET 1 OF 1

PART NO.	PART NAME	SUBASSEMBLY USED ON	RELEASE APPROVAL	ENG. RELEASE
33018	GUARD	33000	A.E.N.	

WRITTEN BY	CHECKED BY	APPROVED	DATE	DATE RELEASED TO PROD. CONTROL
NAVARRD	E.J.MILLER	H.J.D.	5–31–46	5–26–46

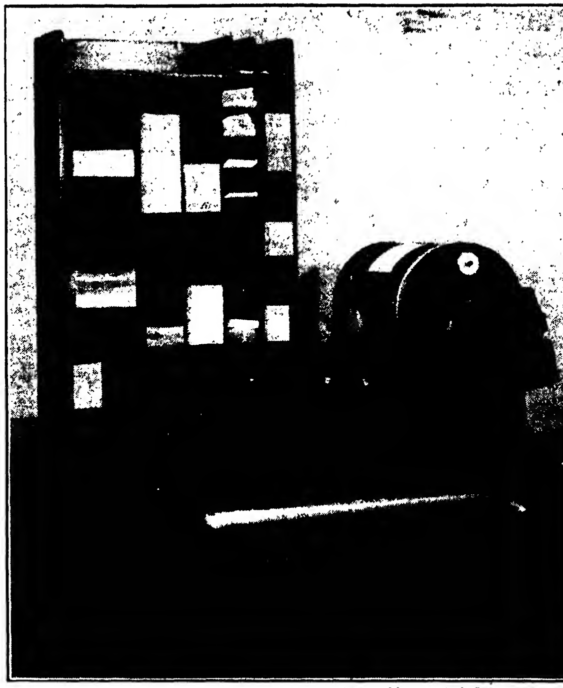
MATERIAL DESCRIPTION	MAT. SPEC. NO.	MAT. CODE NO.	ENG. CHANGE ORDER NO.	ENG. CHANGE DATE
0.032 × 2 3/8 × 3 3/8 –52–S AL. ALLOY (PINK-BLUE)	1103	26333		

OPER. NO.	OPERATION DESCRIPTION	DEPT.	GROUP	MACH.	EQUIPMENT DESCRIPTION · TOOL, JIG, GAGE OR FIXTURE NUMBER AND DISCRIPTION	PIECES PER HR.	STD. HR. PER 100 PIECES	CLASS	STD. SET-UP TIME	NORMAL MCH. HRS. PER 100 PCS.	NORMAL MAN HR. PER 100 PCS.
1	Pierce and Blank	414	6	517	#3½ Toledo Punch Press Piercing and Blanking P & D	600	0.166	T	0.5	0.166	0.166
					T.41624 Bolster 1003						
2	Form	414	6	1181	#3½ Toledo Punch Press Forming P & D 41625	333	0.300	T	0.5	0.300	0.300
					Bolster 1001 Checking Gauge 48695						
3	Burr and Wash	440			Polishing Jack Tank	200	0.500	T	–	–	0.500
4	Inspect	475			Bench Checking Gauge 48695	200	0.500	T	–	–	0.500
5	Anodize as per Spec. #26 (Send Outside)										

DATE OF LAST PREVIOUS CHANGE

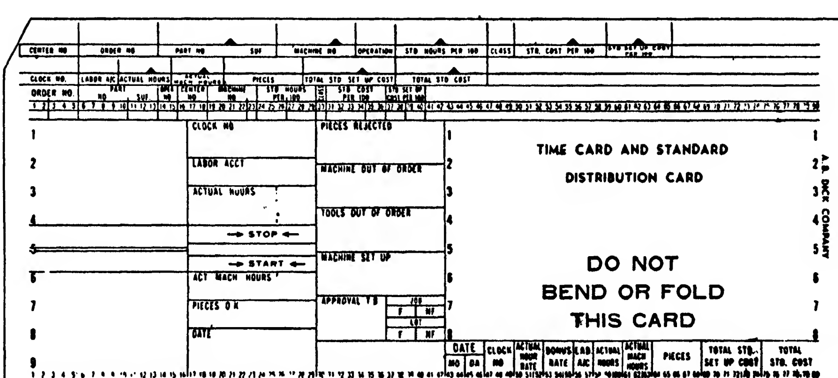
Courtesy, A. B. Dick Company

FIG. 35.5. Route sheet, showing specifications and operation standards.



Courtesy, A. B. Dick Company

Fig. 35.6. Mimeograph 92 duplicator equipped with industrial feed table, roll type feed, knife retainers, industrial hand wheel-collating rack, and convenient work surface.



Courtesy, A. B. Dick Company

Fig. 35.7. Punch card used in production control. This card records hours worked, pieces approved and rejected, and machine setup time. Other cards may cover almost any other data.

struction sheets, and other forms are prepared and filed for future use.[8] These master cards cover every phase of production control when a complete punch-card system is used and are not changed until the product or some operation is changed. They are made up in advance of use. When an order for production is received, these master cards are used to duplicate the necessary forms, orders, and instruction used in production. The cards are released to the factory and, when returned, provide data in detail for payroll, cost determination, material control, and production control for later jobs. When the volume of production justifies the installation, this method of production control, cost collection, and payroll computation offers real economies. It is particularly valuable in cost determination for parts, subassemblies, and the finished product. Much of the duplicating of orders and forms is performed by mechanical means after the initial master card is made.

Relationship between routing and scheduling. It is desirable in routing to observe closely the conditions of the plant schedules to avoid leaving too much leeway in the selection of equipment and too much of the adjustment function to dispatching, which is largely a routine, clerical job when routing has been carefully and adequately done. After the original routing is done in mass production, the scheduling and dispatching function is frequently performed by the same person, particularly when activities are divided on a functional basis. In routing, an attempt is always made to prevent the utilization of a large, expensive machine for a small job that can be done on a small machine; and yet, if the schedule of work is not providing operations for the large machine and is overcrowding the small one, the route man must take this situation into account in designating the path that material will follow. Although he desires always to use the machine that is best fitted for a particular operation, there is ordinarily no object in having machines idle while others have jobs waiting.

Use of route charts. Standard route charts, which set forth graphically in definite order the operations, materials, machinery, and grades of labor required to make a finished product in the most economical manner, are utilized at times, particularly for new plants or departments. They serve as a valuable guide for the installation of the new production-control system and for the instruction of new employees, as a permanent record, and as a guide in drawing up route sheets for individual orders. They are most practicable with standard repetitive products but can be used

[8] See Kenneth Porteous, "Factory Orders and Inventory Records," *Factory Management and Maintenance,* Vol. 95, No. 9, September, 1937, pp. 69–80, for a description of the system used by the Union Switch and Signal Company, Swissvale, Pennsylvania.

profitably in any plant where the sequence of operations is similar, although particular operations may vary. On such charts the operations are so set forth that their sequence is made perfectly clear, and, if the product is assembled, the sequence of assembly of the various parts is carefully shown.[9] All independent groups of the finished product are so separated that those operations which may be performed independently may be seen at a glance. Generally the following information is included: materials needed, with symbols; operations, with numbers; and best machines or equipment for their performance.

A combination schedule and route chart provides for the charting of all operations and assemblies in proper sequence upon a scale, which is so computed toward the left from final assembly that reference to the chart will indicate exactly when any component must be placed in production.[10] This chart is so devised that the necessary operations upon components and the subassemblies into which they go may be performed in time to have them meet with other components for semifinal or final assembly on schedule. Such a chart is extremely valuable if shop conditions permit a smooth flow of work.

[9] See Ralph Currier Davis, *Industrial Organization and Management,* Harper and Brothers, New York, 1939, Chapters 12, 13, 14, and 15, for an interesting discussion of production control. See especially p. 274 for a "manufacturing assembly diagram."

[10] L. P. Alford, *Cost and Production Handbook,* Ronald Press Company. New York, 1937, pp. 245–257, 260.

CHAPTER 36

PRODUCTION CONTROL—SCHEDULING

Scheduling is the allocating of time. The plant engineer allocates floor space; the route man prescribes the path of an item through production and the sequence of operations; the schedule clerk allocates time or designates the time factor for specific operations. The most familiar form of schedule control is that of the railroads. The processes of industrial scheduling are essentially similar. Predetermined schedules control the operations of the offices of railroad dispatchers. Similar schedules control the dispatchers of industrial production. Factory scheduling involves essentially the same elements. There are regularly scheduled orders of varying importance to be taken care of. In addition special orders and special conditions must be met as shop conditions change or as the regular schedule is interrupted.

Professor Henry P. Dutton has said:

> Before an intelligent plan can be made for the production of an order, at least the following steps must have been taken:
>
> *a.* The translation of the order into terms of shop requirements. This involves editing the order into terms of shop pattern numbers, symbols and so on, also the preparation of parts lists and process analyses.
>
> *b.* The matching of requirements for materials, machine capacity and other elements against the shop capacity. This involves first, the check of parts lists against stock records and second, the setting aside of the required hours of productive capacity, after consideration of the reservations already made for other orders. Consideration of this stage may involve increases of permanent capacity, when warranted.
>
> *c.* Scheduling as shown above described, depends upon the securing or possession of knowledge of machine capacities and rates of output and is limited in its precision by the ability to maintain accurately the predicted rates of output.[1]

Professor Dutton's first step is essentially clerical and follows prescribed patterns and procedures. The second step is concerned primarily with scheduling. The third lists the foundation upon which scheduling

[1] Henry P. Dutton, *Trends in Production Control,* an address delivered before the Annual Convention of the Society for the Advancement of Management in New York, October 5, 1939.

rests. There are two distinct parts to production scheduling. The first, a carefully drawn master schedule which indicates the relative importance of manufacturing orders, may be developed before or coincidentally with routing. The second is the determination of the order of work, that is, the order in which each job is actually done at every work place. This phase of scheduling follows routing in performance and is carried on either before or coincidentally with dispatching. *The determination of the order of work is primarily a scheduling function, whereas the actual releasing of the orders that start the work in the factory is a dispatching function.* Inasmuch as these functions are frequently carried on coincidentally, it is difficult entirely to separate the two in a discussion. However, in so far as they may be separated, the planning function in its elements, rather than in a particular situation, will be clarified.

The master schedule. Manufacturing orders originating from direct customers' orders, or as part of manufacturing budgets, should be so arranged that the plant may be operated at its maximum manufacturing effectiveness. If possible, each productive unit should be so provided with work as to allow it to be operated continuously. Primarily, however, sales requirements must be met. When a company is operating on a complete budgetary basis, the master schedule is an extension of the budget. It is no exaggeration to say that the sales department, when operating within the prescribed company policies, provides the data or raw material from which the master schedule is built. Since the annual or quarterly budget cannot give details of customers' orders not as yet received, it is particularly necessary that close cooperation exist between the scheduling division of the production-control department and the sales department in cases in which a plant manufactures both to customers' orders and to stock. This fact indicates that, if the production manager does not directly control scheduling, the person who does must sit, along with the production manager, on such committees as deal with the coordination of efforts of the sales and production departments.

The man in charge of scheduling has more frequent contacts with the sales department than any other member of the production-control department, especially in a company manufacturing a standard product. In large plants the production-control manager may deal more with broad policies than with specific sales orders. In such an enterprise the arrangement of the production schedule may be entirely a function of whoever is in direct charge of scheduling production. Manifestly, in small plants the production-control manager himself will directly control scheduling.

In the development of a master schedule careful cooperation with the sales department is essential, in order not only that information concern-

ing sales needs from the delivery standpoint may be considered, but also that information concerning prospective orders may be secured.

Master schedules in plants manufacturing for customers' orders. In plants manufacturing primarily to customers' orders most of these orders are subdivided into some such general classes as the following: rush, regular, repair, and stock. Any order falling into one of these classes will, in general, be given precedence in accordance with its class, which rank in the order enumerated.

Rush orders include those which are received with necessary delivery dates so stipulated that the product will not be available for shipment on the required date if it follows the regular production routine. It must either have special handling or be worked on overtime to meet the shipping date. In spite of the efforts of executives this class of orders seemingly never can be completely eliminated. Rush orders also include those on which there has been a tie-up somewhere in the production process, so that the order is behind its previously determined schedule, particularly when delivery promises have been made contingent upon adherence to that schedule in the manufacturing process.

By *regular orders* are meant customers' orders on which delivery dates that fit into the usual requirements of factory production are specified. Such orders ordinarily take precedence over repair orders on goods already sold, although there may be circumstances under which these repair orders will even be placed in the rush class.

In some automobile plants repair parts for the service department are manufactured in a separate division for all models other than the one which is currently in production. If there are many repair orders, they may be put through on an entirely different manufacturing basis and, in large plants, in different departments from regular orders.

Master schedules in plants manufacturing for stock. In a plant that manufactures a variety of standard items for stock the manufacturing budget forms the basis of the master schedule. This carefully drawn estimate of production serves as the basis for the development of the master schedule. Such a plant has a flexibility of scheduling that is not possessed by the factory which operates primarily to customers' orders.

The manufacture of materials for stock implies even a closer liaison with the sales department than does the production of orders directly to fill customers' demands. It also implies a closer relationship with the policy control of the company, since, in order to schedule a product which has not yet been sold, it is necessary to have a definite knowledge of future company sales and production policy, as well as of the financial affairs of the plant. It is not to be assumed that those in charge of the preparation of the master schedule will have all this information. They

will, however, be governed by their demand-estimate procedure, which will have been so worked up as to include this detailed information concerning company policy whether or not there is a general budget.

Companies which wish to avoid production tieups and which operate on the basis of manufacturing to stock usually have their schedules developed months in advance. These schedules are generally based on expectancy for some such period as three months, with actual releases for purchased materials for only one month in advance. At the end of each month a review of the stock of finished products in the warehouse is made in comparison with the sales for the current month and the reasonably expected sales for the next period. The schedule may be continued, revised upward or downward in the light of the monthly review. Producing for stock from a master schedule may be viewed as a replacement program. The schedule provides replacements for the withdrawals that are expected to be made during the period involved. Since these withdrawals are greater during certain months than others, the schedule anticipates this unevenness and builds up a reserve in the warehouse to meet any unusual demands. When adequate funds and storage space are available, the master schedule may be developed as an aid in stabilizing employment. Unless some arrangement is made whereby these schedules may be readily changed, it is very likely that financial difficulties may be encountered because a portion of the working capital is tied up in raw material awaiting processing or in finished products. The close liaison necessary between the scheduling function and the balance-of-stores function is evident.[2] There must be continual conferences between those in charge of these two phases of control.

The master schedule should not be looked upon as something rigid into which a new order finds a definite place upon its receipt in the shop, that place never to be changed. On the contrary, it should be regarded as a continually flexible piece of shop mechanism, which is modified week by week, perhaps day by day, as conditions change with the receipt of new orders, the completion of old ones, or the development of some new condition in the shop.

Master schedules based upon productive capacity. On unstandardized, diversified products the master schedule may be set up in terms of hours of work ahead on given classes of products. Such information, which may be termed the balance of work ahead, can be easily communicated to the sales department. If accurate data have been accumulated regard-

[2] Because of the close cooperation necessary between the balance-of-stores-ledger clerk and the scheduling clerk, it is quite common to find both in the production control planning department.

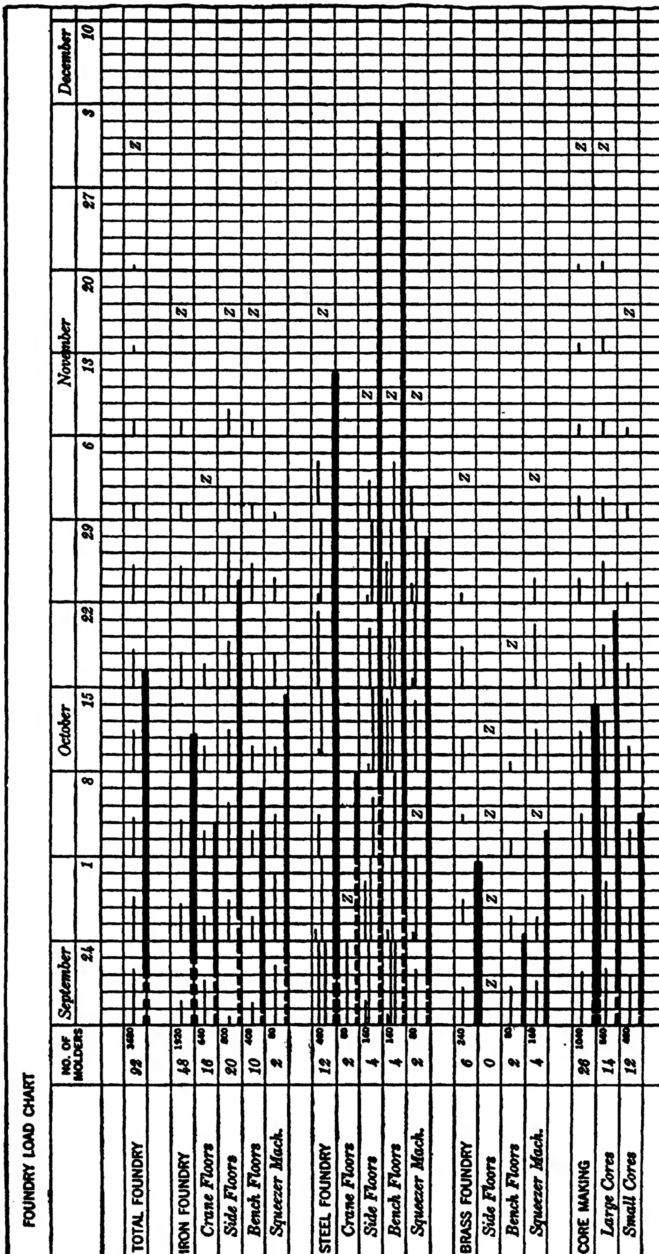
ing machine productive capacities, these data may be used as a basis of the master schedule. Machine-tabulation control methods described in Chapter 35 are particularly well adapted to indicate the number of hours of work ahead of machines. In making sales, the sales department can deduct the time required for manufacture of the product from the balance and thus can always know the unfilled capacity of the plant which it may sell. Such a program involves determining everything, by departments, in terms of the hours of time it takes to produce the product. The sales department must be kept constantly informed concerning this situation. In a sense the sales department sells departmental time rather than products, and the scheduling work is concerned with time rather than with products.

Issuing of manufacturing orders. A single manufacturing order may cover only a portion of the manufacturing budget for a particular article, or it may combine two or more customers' orders for the same article.[3] Thus small customers' orders or large stock orders are increased or subdivided into profitable manufacturing quantities. The shop does not care who gets the finished product; it wants to know how much is wanted and when the order is needed. This information usually is stated on the manufacturing order, and the due date which is placed upon it corresponds to the sequence of the master schedule. It is thus clear that the master schedule must be so arranged as to indicate (1) the due date of all orders, (2) groupings of orders into broad classifications of importance, and (3) subdivisions of groups in accordance with particular circumstances, such as the time required to manufacture.

The Gantt chart. The creation of a schedule based on standard hourly production, and the ability of a sales department to keep manufacturing departments constantly supplied with orders, are greatly facilitated through the use of Gantt Load Charts,[4] similar to the illustration (see Fig. 36.1). This chart, which illustrates the scheduled load of a foundry, shows the status of work as of September 19. The first line for total foundry shows

[3] Some manufacturers, particularly in the clothing industry, release production to the processing departments in quantities measured in terms of the producing capacity of the departments on a time basis, such as one hour. These releases are known as "blocks" and may be made up of several customers' orders combined to give the hour's work, or it may be only a part of one customer's order, depending of course on the size of the orders. Other manufacturers in mass production release orders in terms of lots which may cover a part of a day's run or several weeks' run of the same part or product. All labor and material that can be allocated to the lot is charged to the particular lot number. This system ties in well with the cost-control program. The releases and schedules of the materials are in terms of the lot.

[4] See Wallace Clark, *The Gantt Chart,* Sir Isaac Pitman and Sons, Ltd., London, 1938, for an excellent discussion of the use of charts in production control.



Courtesy, Charles A. Koepke, "Plant Production Control"

FIG. 36.1. Gantt chart for a foundry.

that there were 92 men, who, when working a 40-hour week, had 3680 productive hours available. The narrow lines indicate the work scheduled for each week, and the heavy line the cumulative total of work ahead of the foundry. This chart also shows a breakdown of each of the foundries and the different floors or divisions in each foundry. For instance, in the iron foundry there were 16 moulders, having a total of 640 productive hours, on the crane floors. They were behind schedule, as shown by the broken heavy line. The total amount of work ahead, however, was not excessive, being only about 2½ weeks' work if the men could keep at it without interruptions. The moulders in the steel foundry on the side floors were about 2¾ weeks behind schedule. The letter *Z* indicates the date beyond which no work was scheduled, yet the heavy line for the moulders on the side floors in the steel foundry shows that it would take them 3 weeks beyond their scheduled date to get out their production. A glance at this chart tells the schedule man where he needs to work to keep his men busy and also where he is behind schedule.

The same Gantt charting technique may be used for recording inventory controls and the progress of any particular item or product through production. The charting technique is particularly valuable in emergencies, at the start of a new job, or during rapid expansion. They are often appreciated by a busy executive who wants a quick picture of his entire operations. There are mechanical boards that merely duplicate the Gantt principle (see Fig. 36.2). When operations are proceeding smoothly, it is likely that neither the Gantt charts nor the mechanical boards that show the progress of production will be kept up to date. Such devices are worthless unless they indicate current conditions.

Another method of keeping a record of the hours scheduled ahead of a machine is a simple card type of ledger for each machine or group of similar machines in a work center (see Fig. 36.3). It is somewhat simpler than the Gantt chart and is well adapted to a small enterprise. Figures 36.4 and 36.5 illustrate two other methods of keeping production records.

Detailed scheduling or prescribing the specific order of work. The preparation of the order of work differs from the development of the master schedule, inasmuch as it concerns itself with detailed operations of manufacture of a product, rather than with the completed product. The control exercised by the master schedule emphasizes bringing the final delivery date to such a point as to coincide with the needs of the sales department. The development of the order of work should control the step-by-step progress of the job through the factory so as to bring the finished product through the process of manufacture in time to meet the needs set down by the master schedule. *Changes are but infrequently made in the master schedule, as compared to changes in the order of work.*

Courtesy, Automobile Manufacturers Association

FIG. 36.2. Machine load board.

MACHINE LOAD CARD LEDGER

Machine or Production Center

Week Ending 1-10 Hours 40 | Week Ending 1-17 Hours 40

Mfg. Order Number	Part Number	Hours for Order	Load Hours Left in Week	Mfg. Order Number	Part Number
8092	21	3	37	9341	89
9183	104	30	7		
9341	89	* 7	0		

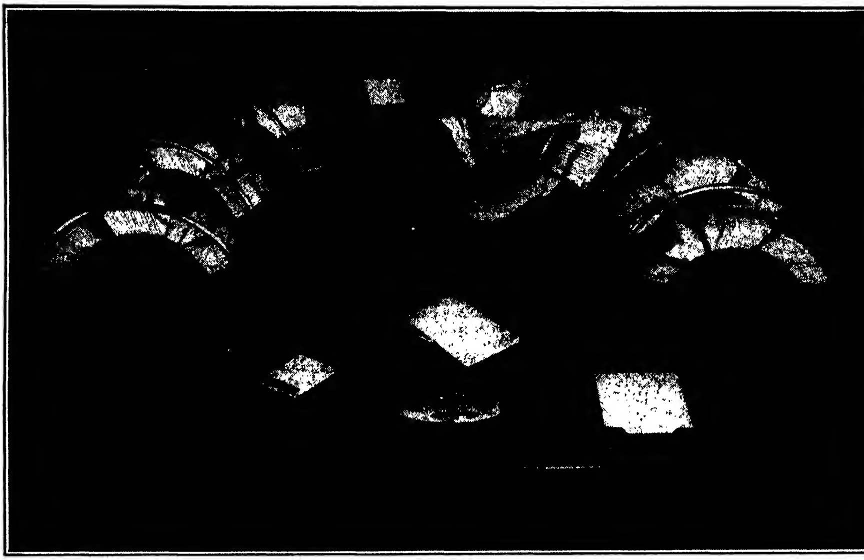
* 15 Hour job
8 Hours carried over to week ending January 17.

Courtesy, Charles A. Koepke, "Plant Production Control"

FIG. 36.3. Machine load ledger.

The order of work reflects the ebb and flow of factory conditions. If a machine is broken down or a workman is absent, the order of work on another machine or for another workman may be changed in order to meet the needs of the current schedule. On the other hand, such small recurring factors do not in any way affect the master schedule.

The routing of a given part or assembly must not be confused with the scheduling of the order in which different work is processed through the



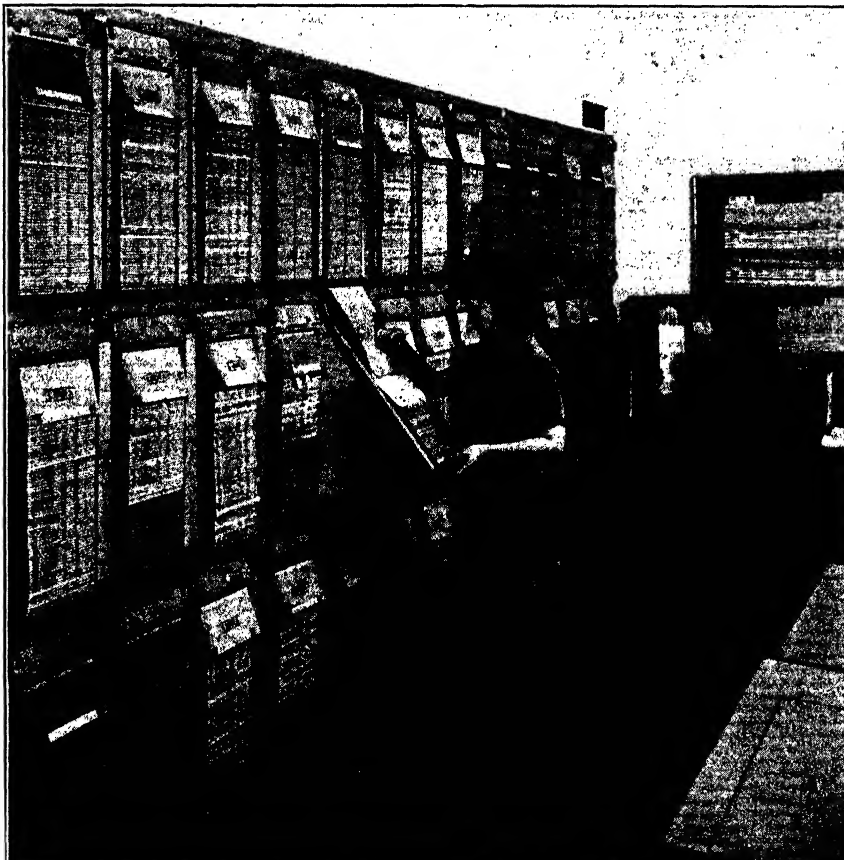
Courtesy, Diebold Incorporated

FIG. 36.4. A Cardineer installation used in scheduling.

shop. In the development of the master schedule the orders must necessarily be arranged in accordance with their relative importance. In determining the order of work the operations must be arranged with consideration of the amount of work which must be done on each and the conditions which exist in the shop, as well as the date when the final work on each order must be completed.

The relationship of the schedule clerk to the line officers. With centralized planning, the foreman comes into contact with the order of work but infrequently. In decentralized planning, the foreman often makes out the order for his own department. In centralized planning it is most necessary that the foreman be given the responsibility of taking up with the planning department any order of work which he may feel is illogical. When dispatchers other than the schedule man are used in centralized production control, the contacts of the foreman are with the dispatcher or the follow-up man. It is highly important that this be a cooperative

relationship, for the man operating the department often can suggest ways of facilitating production at a reduced cost without interfering with delivery dates.



Courtesy, Crucible Steel Casting Company

FIG. 36.5. Visible index records used in production control.

The work of scheduling culminates in reports given to the works manager and other major executives of the concern. Besides a "balance of work" or "load ahead" report, which indicates unapportioned capacities, reports may be made at intervals by the scheduling division to show:

1. A detailed list of all customers' orders in process.
2. A detailed list of all stock work in process.
3. A detailed statement of causes of delay or changes in the order of work which have held up production and which may be remedied or improved by executive action.

CHAPTER 37

PRODUCTION CONTROL—DISPATCHING

Dispatching. Dispatching includes the execution of all the plans of the routing and scheduling sections of the production-planning and control department. It consists largely of transmitting orders to the shop and is carried on concurrently with the operation of the schedule or order of work, but is purely a clerical function. Except in large plants the operation of the order of work and dispatching are likely to be carried on by the same individual. For clarity of illustration these functions will be discussed as if handled by two persons.

Illustration of central production control using planning boards. For illustrative purposes it is best to describe one basic system, although it is fully realized that there may be many modifications of the system described. This system will presume central operation of all phases of planning in a shop in which the nature of the product and orders makes necessary complete control of each separate operation. The type of jobs and size of lots are varied and are such that the operations are long enough to make this control profitable, yet short enough to allow at least three jobs to be planned ahead of each machine or workman. Changes in these basic conditions would necessitate changes in the system. This system indicates the factors in production which must in some manner be controlled by the order-of-work clerk and dispatcher. It will be described in full detail, including all forms which are necessary for its operation. The factors which must be controlled include the equipment, raw and worked materials, tools, instructions, inspection, shop transportation, and sometimes the workmen. Study of this system is particularly valuable because it clearly controls each of these factors separately and thus clarifies systems which combine control over several factors in production. The fundamentals of this system are probably used in more planning departments than those of any other, and many other planning systems are clearly developments which use this one as a basis.

The greatest aid in operating an order of work is some sort of continuous visual check on the condition of the shop. The type of check here described is known as a bulletin board, or planning board (Fig. 37.1). Through the operation of this bulletin board or its equivalent, those in charge of the order of work and dispatching have always before them

an accurate picture of shop conditions and, through the added aid of the route sheets, the status of all orders. The planning-department bulletin board pictured is known as the three-hook type. Pairs of hooks are

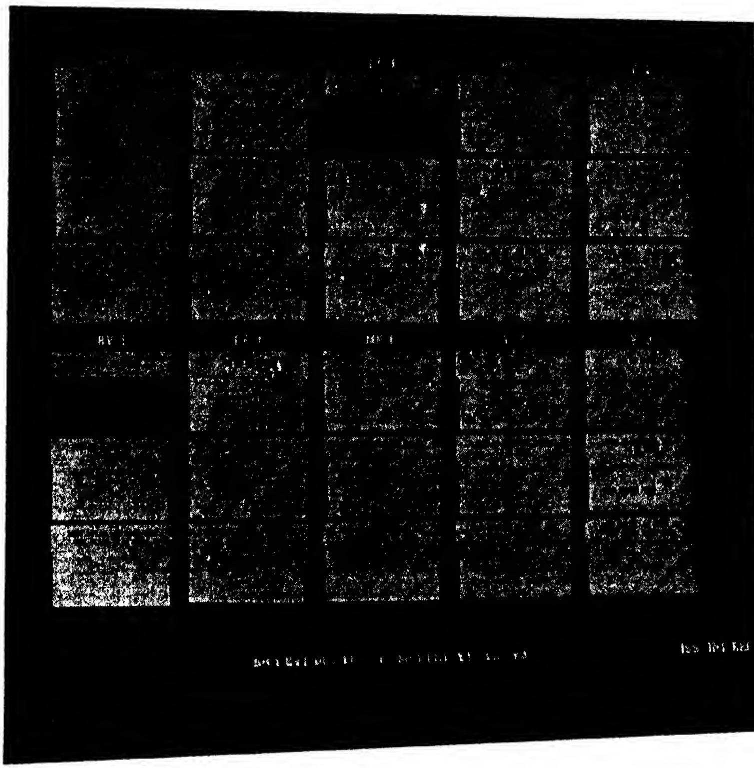


FIG. 37.1. Section of planning-department bulletin board.

arranged in vertical rows in sets of three for each machine or work station. Each pair of hooks is utilized to indicate the position of work in the shop with respect to that particular machine or work place. These hooks will be referred to as the first, second, and third hooks; they represent work in the following stages:

1. The work which is on the machine.
2. The work at the machine ready to be started.
3. The jobs ahead in the shop and tentatively assigned to the machine or work place.

The lower portion of the board consists of a number of small compartments, one for each work station shown on the board, and other compart-

ments for miscellaneous uses. The compartments in the center of the board, which correspond to the machines or work stations which the board controls, are utilized for filing tickets relating to work assigned to the particular machine. The three compartments to the right are used for temporary filing of tickets that control the issuance of tools, drawings, and instructions. The other compartments are used for miscellaneous purposes.

In each department of the shop there may also be found a bulletin board (Figs. 37.6 and 37.7) which displays information concerning work for each machine or work place in the department. This departmental bulletin board may be regarded as a replica of the section of the central bulletin board which deals with the department. It is set up in the department for the purpose of more readily correlating the activities of the shop foreman and the central planning department and does not imply decentralized planning, although similar bulletin boards are frequently used in the departments when production control is decentralized.

Indicating the order of work. The schedule man constantly aims toward the master schedule, from which he determines the time when it is necessary to place an order or a component of an order in production. He must consult the route sheets pertaining to the order for the path to be followed through the shop. In operating the order of work, he must constantly consult the route sheets, since any determination of the time when an operation is to be performed must rest largely upon the availability of the machines or workmen involved. When an order is to be started, he must first consult the route sheets to ascertain whether material is available. He can determine this by consulting the checkmarks which have been placed on the route sheet opposite the heading, "Material Apportioned and on Hand." If he is dealing with an assembly operation, he consults the assembly route sheet and there ascertains whether the necessary material has been checked, "O.K." All such checks will have been made by the balance-of-stores clerk, who, since he controls stores, will be in a position to place this necessary information on the route sheets. If material is available, the order or component may be placed in production.

To place an order in production involves taking from the files certain of the dispatching tickets, which were prepared at the time the order was routed, and starting them through the routines which they affect. These tickets include *material requisitions, identification tags,* and *move tickets.* The requisition forms were partially considered when the operation of the storeroom was described. They are prepared from the route sheets or bill of materials and filed. Before being filed, however, they pass through the hands of the balance-of-stores clerk, who utilizes the infor-

mation on them to increase the Apportioned column of the proper balance-of-stores sheets, correspondingly to decrease the Available column, and to take such other steps as may be necessary, for instance, to order materials. When the order-of-work man removes the stores requisitions from their file, they again pass through the hands of the balance-of-stores clerk, so that he is enabled to write off the material which is being issued from the On Hand and Applied on Orders columns. The forwarding of requisitions to the storeroom is a function of dispatching. Usually, it is only necessary for the order-of-work clerk to place the

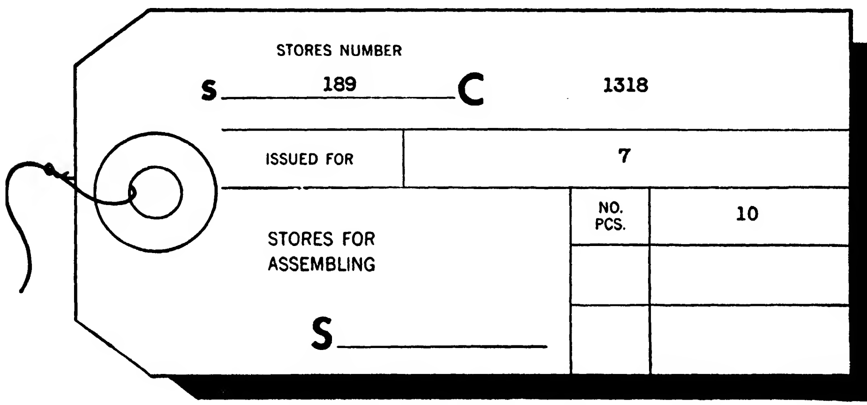


FIG. 37.2. Identification tag.

requisitions in a designated place, which will indicate to the dispatcher that these slips are to be forwarded to the storeroom and the corresponding orders thereby placed in production.

When the dispatcher sends a stores requisition to the storeroom, he sends along with it the necessary number of stores-identification tags, which have already been prepared and filed (Fig. 37.2). Such tags are attached to all stores issued and stay with the materials throughout the production process, thus clearly identifying them with the production order on which they are being used. The move ticket (Fig. 37.3) is then sent by the dispatcher to those in charge of interior shop transportation, as authority to move the material in question from the storeroom to the department and production center where the first operation is to be performed. If the route sheet indicates alternate machines on which a given operation may be done, the writing of the move ticket is at times left to the dispatcher, who selects the machine by consulting the planning board regarding availability. Identification tags and move tickets are often profitably combined.

The set of check columns on the route sheets used for recording the performance of designated operations now comes into use. The columns are headed "Move," "Operation," "First Inspection," and "Final Inspection." A check is made by the dispatching clerk when he orders the performance of any of these functions on any operation indicated as neces-

<table>
<tr><td>DM 14
IN
OUT</td><td colspan="3">C 1318</td></tr>
<tr><td colspan="2">PIECE NUMBER</td><td colspan="2">189</td></tr>
<tr><td colspan="2" rowspan="3">MOVE THIS MATERIAL AS DIRECTED:
W______
S</td><td>NUMBER PIECES</td><td>10</td></tr>
<tr><td>DRAWING NO.</td><td></td></tr>
<tr><td>MACHINE NO.</td><td>91</td></tr>
<tr><td colspan="4">FROM Stores ON ______ FLOOR
TO 9 ON ______ FLOOR</td></tr>
<tr><td colspan="4">WORKMAN'S NAME ______ MAN'S NO. DM ______</td></tr>
<tr><td>ROUTE SHEETS</td><td>PAY SHEET</td><td>COST SHEET</td><td rowspan="2">I HAVE MOVED THE MATERIALS AS ORDERED ABOVE

SIGNED ______</td></tr>
<tr><td></td><td></td><td></td></tr>
</table>

FIG. 37.3. Move ticket.

sary by the route sheet. For instance, when he issues the move ticket and orders the materials from stores to the first operation, he may draw a vertical line halfway down the small space under Move and opposite the first operation, thus indicating that he has ordered this action. When the move has been completed, those in charge of shop transportation return the move ticket to the planning department, noting upon it that the move has been made. The dispatching clerk may then transfer this information to the route sheet by completing the vertical check under Move and opposite the first operation. Anyone who consults the route sheet

will therefore be informed immediately concerning the status of the order at that time, namely, that the material is at the machine ready for the first operation, but that this operation has not yet been performed.

Immediately upon receipt of information in the planning department that material has been moved to a production center, the scheduling function of indicating the order of work again becomes important. At the time when the order was routed, there were placed on the third hooks of each machine or work place affected by the order triplicate copies of an operation ticket (Figs. 37.4 and 37.5). This ticket describes and controls

	OPERATION ORDER	C	1318	
	OPERATION NUMBER		7	
	TO EARN BONUS, WORK MUST BE DONE IN	2.48	NO. PCS.	10
	AMOUNT OF BONUS		DRAW. NO.	53748
IN OUT	WANTED FOR		MACH. NO.	91
	HOLD FOR			

FIG. 37.4. Operation ticket.

the operation to be done on the machine in connection with the order. The tickets hanging on the third hooks at any time clearly indicate the balance of work ahead of each machine or department not yet engaged in production. If alternate routing to a group of machines is provided by the route sheet, the operation tickets usually are hung on the third hooks of one machine of the group previously designated. When material is moved to a production center, the order-of-work man must remove the proper triplicate set of operation tickets from the third hook and place two of them in proper sequence on the second hook. *The position in which he places them on the second hook determines the order of work for that operation on that machine in relation to other operations already scheduled for the machine.* He determines the position according to the needs of the master schedule. The two copies that are placed on the second hook are the planning-department bulletin-board copy (white in color) [1] (Fig. 37.4), which primarily controls sequence, and the drawing, tool, and instruction card issue copy (pink in color) (Fig. 37.5). At the

[1] Any color combinations may be used.

same time that these two copies of the operation order are placed upon the second hook, the manila or shop bulletin-board copy is taken to the shop board and placed there.

The shop bulletin board illustrated in Fig. 37.6 consists of two sections: on the right a series of pairs of hooks serially numbered; on the left a series of clips under headings for each machine or work station in the shop. When the shop copy of the operation order is placed on the shop bulletin board, it may be hung on any one of the serially numbered pairs of hooks which may at the time be vacant. At the same time that

DRAWING AND INSTRUCTION CARD ISSUE	DM 3 OPERATION ORDER		C	1318
OPERATION NUMBER			7	
NUMBER OF INSTRUCTION CARDS		1	NO. PCS.	10
NUMBER OF TOOL LISTS		1	DRAW. NO.	53748
ISSUED BY	RECALLED BY		MACH. NO.	91
SIGNED	SIGNED			

FIG. 37.5. Operation ticket. Drawing, tool, and instruction card issue copy (pink).

this operation order is placed on this pair of hooks, there is placed under the machine heading a strip of cardboard on which is found a number corresponding to the serial number of the hooks on which the operation order is hung. The relative position of this strip of cardboard to other similar strips under a machine heading indicates the order of work for the machine and corresponds exactly to the order of work as found on the second hooks of the planning-department board. Another form of shop board, used at the Universal Winding Company, as illustrated in Fig. 37.7, provides for the placing of operation orders in sequence directly under the machine numbers. Either method gives the necessary flexibility of operation.

Conditions of a particular shop will determine the number of operations for which material should be on hand at any production center, and also the number for which tools, drawings, and instruction cards should be on hand. Unless the tools are special, they will be used on more than one operation, and it is, therefore, not wise to have too many waiting at the production points. The pink operation ticket controls the issuance of the tools, as well as the drawings and instruction cards. The handling

of this ticket depends largely upon shop conditions and the number of jobs ahead of particular machines. It may not be placed upon the second hook at all, but may be used immediately to order the tools, drawings, and instruction cards to the shop. Or, if there are a number of operation tickets on the second hooks, it may be placed on the second hook with

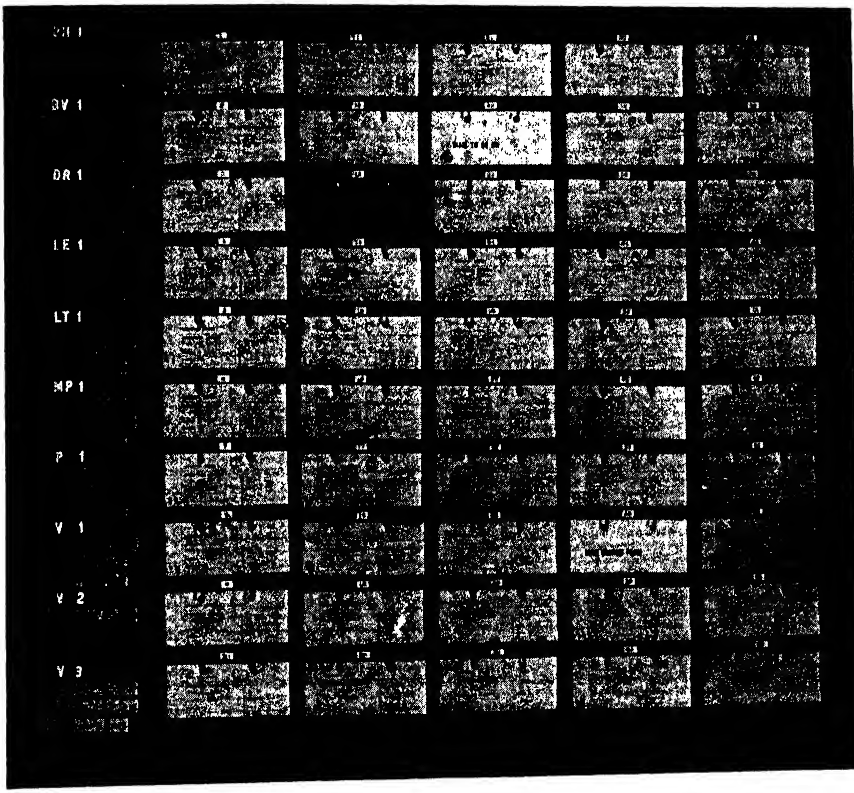


Fig. 37.6. A shop bulletin board.

the white operation ticket, as already indicated, until the job is the second or third ahead. In any case, when it is desired that the tools, drawings, and instruction cards be issued, the pink operation ticket is placed in the small compartment in the lower right-hand portion of the planning board marked "ISS" or issue. These tickets are periodically collected by a messenger, who, consulting them, takes the proper instruction cards and tool lists from the files and any necessary drawings from the drawing cabinet to the work station. The tool lists with the requisite number of tool checks are subsequently forwarded by the foreman to the toolroom,

as a requisition for the necessary tools for the operation. This procedure insures the utilization of standard tools for each operation. The pink ticket is then filed in the central section of the bulletin board under the machine number, thus indicating that the instruction cards, drawings,

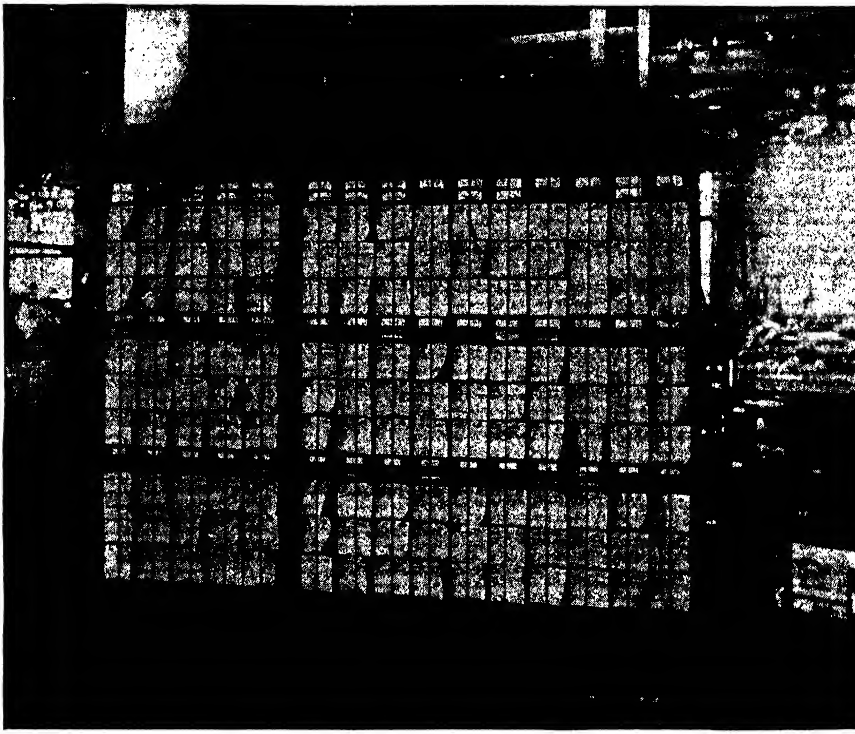


FIG. 37.7 Shop foreman's bulletin board, Universal Winding Company, Providence, R. I.

and tools are at the machine and the operation is thus ready to be performed.

Dispatching to the workman. Let it be assumed that a workman has just completed an operation on a machine. He brings or sends to the dispatch window of the planning department the time ticket (Fig. 37.8) which was issued to him at the same window at the beginning of the operation. This time ticket is stamped with the time of receipt, and the workman is ready to receive a new time ticket for his next job. The dispatcher consults the bulletin board and ascertains which job is next on the order of work on the second hook of that machine. He places this operation ticket on the first hook after removing the operation ticket for

the job just completed. He then proceeds to the route file, removes the time ticket and inspection ticket (Fig. 37.9) for the new operation, hands the time card to the workman, and forwards the inspection ticket to the inspector. At the time that the dispatching clerk hands the time ticket to the workman, he draws on the route sheet a half check line under the headings "Operation" and "First Inspection" for the task. When the workman brings back his time ticket, indicating that the work has been completed, the dispatcher completes this check line. After the inspector makes his first or check inspection, the inspection ticket is returned to

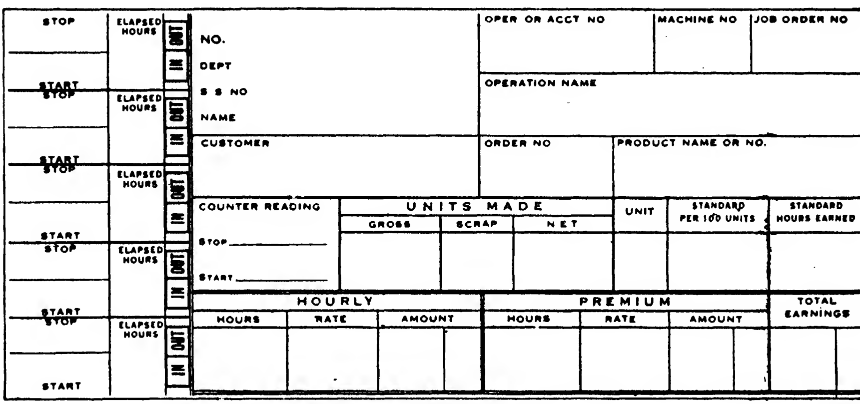


Fig. 37.8. Time ticket.

the dispatcher, who completes the check line under first inspection. This use of the route sheet as a progress chart clearly illustrates the desirability of having it filed in such a manner as to be readily accessible.

Upon receipt of the time ticket from the worker at the completion of the operation, the inspection ticket is reissued to the inspector for recording of the final report concerning quality and number of the lot that is good and can be continued in process, and a half check line is drawn under that column. Upon receipt of the final inspection report from the inspector, this line is completed. The time and inspection tickets are now forwarded to the rate-setting or cost department for addition of bonuses, deduction of penalties, and general payroll purposes, as well as for entry on the necessary cost records.

Upon the receipt of the final inspection ticket from the inspector, the pink operation order controlling the drawings and instruction cards is removed from the receptacle under the machine number at the bottom of the planning board and placed in the lower right-hand corner of the planning board under the heading "REC," signifying recall. This is a

signal to the messenger to bring back all drawings, instruction cards, and tool lists from the machine or work place to the planning department, where they are properly filed. It is a function of the foremen to see that tools are returned to the toolroom at this time.

DM 18 IN OUT	C 1318

FIRST INSPECTION	OPERATION NUMBER	7

I HAVE INSPECTED THE WORK DONE ON FIRST PIECE AND FIND AS FOLLOWS:	NO. PCS.	10
ROUTE SHEETS — MAN'S NO. DM	DR. NO.	53748
SIGNED BY INSPECTOR	MACH. NO.	91

FINAL INSPECTION I HAVE INSPECTED THE WORK DONE ON ABOVE OPERATION AND FIND AS FOLLOWS:	PIECES DELIVERED TO MACHINE	PIECES LOST AT MACHINE	PIECES DAMAGED EXTRA WORK

PIECES DAMAGED NO EXTRA WORK	PIECES SPOILED AT MACHINE SCRAPPED	PIECES DAMAGED STOCK	PIECES SPOILED STOCK	DEFECTIVE CASTINGS	PIECES O. K.

ROUTE SHEETS	BONUS RECORD	PAY SHEETS	MAN'S COST SHEET	PRODUCTION RECORD	SIGNED BY INSPECTOR

FIG. 37.9. Inspection ticket.

Upon the receipt of the final inspection ticket, the move ticket is issued for the next operation as indicated by the route sheet, and a half check line is drawn under the Move Column for this operation. Upon the receipt of this move ticket, those in charge of shop transportation move the worked materials from the machine where the work has been completed to the machine or work place where the next operation is to be performed. They then return the move ticket to the planning department, a full check line is drawn under the heading "Move" for this operation, and all procedures, as explained for the first operation, continue for the second and other succeeding operations in exactly the same manner.

If a job is interrupted and the operation postponed for any reason, the operation ticket is removed from the first hook and placed on the second hook, in conformity with the proper order of work. At the same time all drawings, instruction cards, and tool lists are recalled from the shop, if the delay is to be long. Such recall is accomplished through the removal of the pink operation ticket from under the machine number at the bottom of the planning board. This ticket is placed in the lower right-hand compartment headed "INT," signifying interruption. The messenger, observing the pink slip in this location, brings all papers from the shop and files them.

The planning board gives a picture of shop conditions. The bulletin board, when operated as described, gives a bird's-eye picture of conditions in the shop at all times. A card with the words "No Man" printed upon it may be hung under any machine where there is work to be done, but no operator is available. A "Man Not In" card may be used to indicate that an operator is absent; a "Machine under Repair" card, that a machine is shut down for repairs. These cards are usually in distinctive colors which will enable members of the planning department quickly to visualize shop conditions. Some plants, in place of certain of these cards, prefer a "Machine Inactivity" card, on which the relevant information may be checked. This card may be time-stamped and forwarded to the cost department for computation and distribution of idle-time costs.

Important forms used in dispatching. The time ticket serves more purposes than any other form used in dispatching. It informs the worker of his rate, if this is not on the instruction card. It records the length of time consumed in the operation and is, therefore, a basis for all cost computation and wage payment, and it is a vital link in the dispatching system. The amount of information which must be placed upon it, therefore, is great, particularly in comparison to a ticket, such as the operation ticket, which is used only for control. Duplicate copies of time tickets may well replace operation tickets, unless it is felt that the larger amount of information on the time ticket may lead to confusion, or to using too much space on the planning boards. The order which is to be charged with the labor represented by the ticket must be indicated, as well as the operation number, which will make possible allocation of costs to operations or departments. Provision must be made to indicate the time when the ticket is issued and returned. The time when the job is completed is stamped above the time when it is begun, to permit easy subtraction of elapsed time. If an incentive wage system is used, it is desirable to indicate standard time, the base rate, and the bonus earned on the time

ticket. At the bottom of the ticket there may be check spaces headed "Route Sheet," "Pay Sheet," and "Cost Sheet," to provide for checking proper posting of the time ticket.

One development in time tickets is the use of tabulating-machine cards, as illustrated by Fig. 35.7. All the necessary information can be written on the card; and then, when full use has been made of these data, the card can be punched, on the basis of this information, for use in the tabulating machine. The cards can then be run through the tabulating machines, and information concerning general shop conditions, conditions of work, or wage payment quickly secured. Some plants are using carbon copies of tabulating-machine time cards for control of operations in the usual way.

Many types of planning boards have been constructed. A simple, effective board which uses tabulating-machine cards for time tickets has been utilized by the Paine Lumber Company of Oshkosh, Wisconsin. J. J. Davis, industrial engineer of this company, has described the operation of this board as follows:

> The basis of the scheme is a job card for each operation to be performed on each job or order, on which is entered, on a special line, the time required for the operation. A heavy line of the proper length is then drawn through the scale to represent the time required. . . . On the left of the board all operations performed in the department are indicated by symbols, together with the machines or other equipment upon which they are performed. . . . Across the top is a time scale corresponding to the scale printed on the cards. Hooks at top and bottom of the board hold an elastic tape to aid in locating current time. They are spaced for each half day. . . . If separate cards are desired for several workmen performing one operation, they are all filed together. . . . The cards for each order or lot are separated according to the length of the line drawn on the scale. The time required for each operation determines the time at which succeeding operations may start, and at which similar operations upon other parts should start, and at which assembly may start without being delayed for parts. When all cards for jobs ahead are properly filed, the board then presents a complete picture of work ahead of the department. To aid interpretation of this picture, pink cards are inserted to indicate idle equipment and workers, which are changed to green cards when other work has been provided for the operators. A messenger or workman from each crew comes to the board with cards representing completed order or lot, and takes cards for new orders with complete instructions, leaving exposed a colored card filed back of work cards indicating job in process on each operation. The method of filing cards makes it very convenient to change the plan and provide for machine breakdowns, absent help, variations in actual time consumed on any operations, etc. This feature of flexibility makes it possible to provide for such irregularities and emergencies with the least possible interruption of assembly

or completed work, as well as to lay out the work in one way and then try to work out a better rotation.[2]

Check spaces on forms. A most important part of any form used in control is the series of check spaces provided to insure the performance of all tasks that deal with the information covered by the form. Manufacturing orders, time and job tickets, and other forms which are the basis for a procedure involving two or more persons may all have these check spaces provided. They not only permit quick placing of responsibility for errors made, but also prevent errors and oversight and insure that, once a procedure is started, all necessary steps in connection with it will be taken.

[2] *The Society of Industrial Engineers Bulletin,* Vol. 9, No. 11, p. 3.

CHAPTER 38

PRODUCTION CONTROL IN DIVERSIFIED MANUFACTURING

General considerations. In presenting the details of a complete system of production planning and control in the previous chapters, it was realized that many modifications are made with experience and practice in a given situation. Since the purpose of production planning is to control operations in such a way that they will be performed on time and at the lowest cost, care must always be exercised that control schemes do not slow up production. If the planning system is so arranged that much time is used by the workman in the exchange of job cards, or if an inordinately large clerical force must be provided to handle the planning procedures, the difficulty probably is that the planning has been attempted on too exact a basis and that, in the attempt to reach perfection, costs have been unnecessarily increased. Planning which is ninety-eight per cent effective is likely to prove more profitable than planning which strives to reach perfection. In developing an order of work, if perfection is sought, it is probable that alternate provisions for work which has been planned ahead will not always be ready. In practical scheduling the planning department makes arrangements to take care of the hold-ups which inevitably occur, and therefore in the long run the control of production operations is smoother.

Adjustments to meet special conditions. *It is essential that the form be not misunderstood for the essence.* These chapters form a ready basis for adaptation and simplification. They clearly indicate a unified method of handling all the factors of production which must be currently controlled while an order is in process. One method of developing planning boards has been described in detail. Some companies, instead of using planning boards with hooks, use pockets or boxes for the distribution of tickets controlling operations (see Figs. 38.1 and 38.2). Many plants utilize a two-position planning board, rather than a three-position board, as described. In such cases jobs are not posted until an operation is ready to be performed, the operation tickets being retained in the file until that time. The rest of the work, instead of being secured from a third position, is obtained from some sort of a load chart.

Using a single form for multiple purposes. One of the first steps in consolidating individual forms is the combining of identification tags

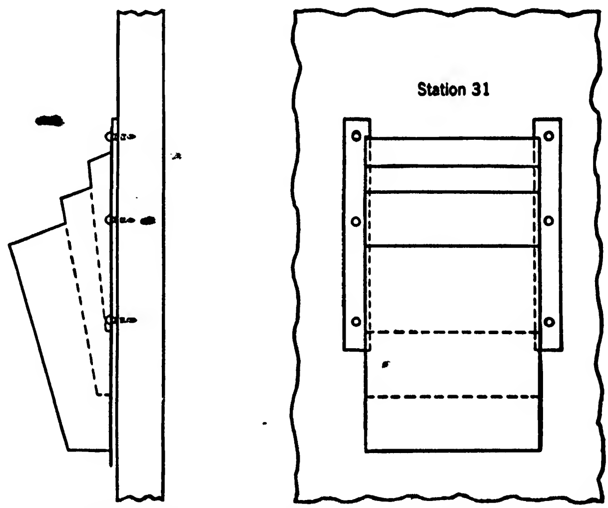
with move tickets, particularly when most of the manufacturing is of a standard nature, even though many different products are made. Since the route that materials are to take is usually determined when they

Courtesy, Charles A. Koepke, "Plant Production Control"

FIG. 38.1. Dispatch station of General Electric Company, Schenectady plant. This type of dispatch station is frequently used in a decentralized production-control system. Note pockets in special desk and special blueprint file.

leave the storeroom, this move is logical. To run off the single ticket containing the additional information takes only half the time required for the two individual tickets. The identification tag may be somewhat enlarged, and on the back may be placed the route through the plant. As one operation is completed, the move may be ordered by the inspector

who has passed the materials, or, if no inspection is needed at that point in the process, as is often the case, the move man may receive orders to move from the shop foreman. In such cases the movement of the material is reported to the planning department at the same time that the inspection report or the job ticket is handed to it. The department has continual knowledge of the location of the material, but it orders the

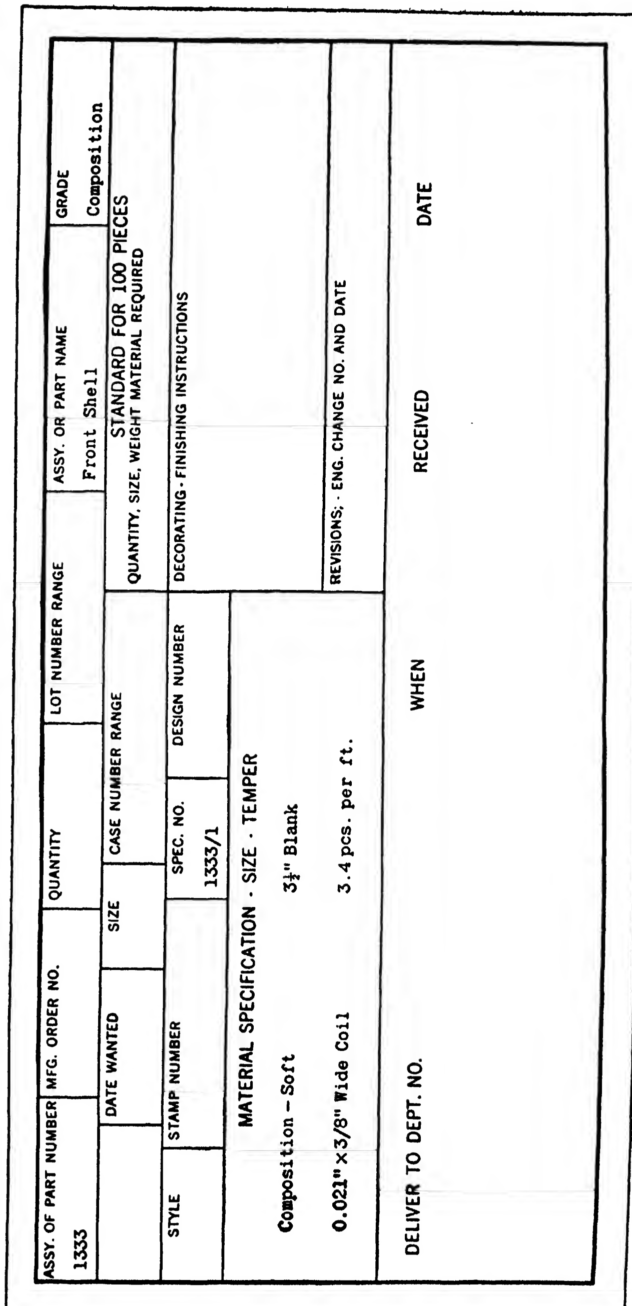


Courtesy, Charles A. Koepke, "Plant Production Control"

FIG. 38.2. Section of a three-pocket dispatch board. A two-pocket or a one-pocket board is constructed essentially the same as a three-pocket board.

movement from each operation at the time that it first orders the goods from the storeroom. If minor changes are needed, they can easily be made on the identification tag when the goods are in process, by a representative of the planning department. Such a tag is illustrated in Figs. 38.3 and 38.4.

Combination time, inspection, and move ticket. It is possible to make almost any combination desired on the same ticket (see Fig. 38.5). One way to use such a ticket is to run off one more copy than there are operations. These copies may be inserted in a celluloid envelope. As each operation is finished; the operator's clock number is filled in, together with the finishing time, the starting time having been filled in as he started. The inspector makes his notation and checks the next operation to be performed on the top sheet remaining in the envelope. The finished operation ticket is sent to the schedule clerk, and the foreman or inspector tells the trucker to take the material to the next operation. The extra copy remains with the work after the last operation is finished. When



ASSY. OF PART NUMBER 1333
MFG. ORDER NO.
QUANTITY
LOT NUMBER RANGE
ASSY. OR PART NAME Front Shell
GRADE Composition
DATE WANTED
SIZE
CASE NUMBER RANGE
QUANTITY, SIZE, WEIGHT MATERIAL REQUIRED
STANDARD FOR 100 PIECES
STYLE
STAMP NUMBER
SPEC. NO. 1333/1
DESIGN NUMBER
DECORATING · FINISHING INSTRUCTIONS
MATERIAL SPECIFICATION · SIZE · TEMPER
Composition – Soft 3½" Blank
0.021" × 3/8" Wide Coil 3.4 pcs. per ft.
REVISIONS; · ENG. CHANGE NO. AND DATE
DELIVER TO DEPT. NO. WHEN RECEIVED DATE

Courtesy, Illinois Watchcase Company

FIG. 38.3. Combination identification and move ticket (*front*).

MOVE TICKET

OPERATION NO.	CLOCK NO.	INSP. APPROVAL	OPERATION NO.	CLOCK NO.	INSP. APPROVAL

FORM 619 2·24·46 5M

Courtesy, Illinois Watchcase Company

FIG. 38.4. Move ticket (*back of Fig. 38.3*).

all the forms for each operation are inserted in the envelope as the work starts, the schedule man does not have quite so close control as when he issues a separate form for each operation, but he can follow the work by checking the ticket sent him after the inspector's count.

STANDARD PROCESS TRAVELER

☐ SUB-ASSEMBLY ☐ ASSEMBLY ☐ PART

ASSY OF PART NUMBER	MFG. ORDER NO.	QUANTITY	LOT NUMBER RANGE	ASSY OR PART NAME	GRADE
1294				Back Shell	Sterling Silver

DATE ISSUED	DATE WANTED	SIZE	CASE NUMBER RANGE	STANDARD FOR 100 PIECES QUANTITY, SIZE, WEIGHT MATERIAL REQUIRED

STYLE	STAMP NUMBER	SPEC. NO.	DESIGN NUMBER	DECORATING · FINISHING INSTRUCTIONS
		1294/6		

MATERIAL SPECIFICATION - SIZE - TEMPER

Sterling Silver – Soft 3.27" Blank

0.021" × 3½" Wide Coil 3.6 pcs. per ft.

REVISIONS: ENG. CHANGE NO. AND DATE

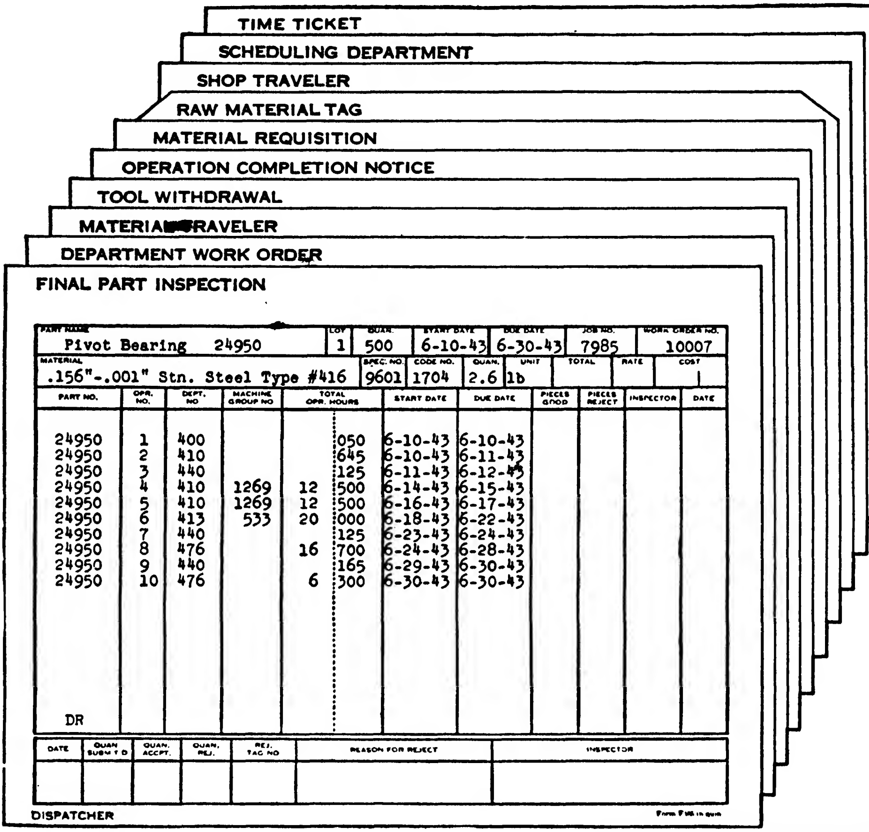
DELIVER TO DEPT. NO 33-1 WHEN RECEIVED DATE

DEPT NO	OPER. NO	DESCRIPTION OF OPERATION	COMPLETED DATE	COMPLETED OPERATOR CLOCK NO.	COMPLETED OPERATOR COUNT	INSPECTED QUANTITY ACCEPT	INSPECTED QUANTITY REJECT	INSPECTED BY	MOVE FROM	MOVE TO
82	1	Move from Stores to Dept. 33-1								
33-1	1-1	Set Up								
33-1	10	Blank								
33-1	10-1	Set Up								
33-1	20	Joint Offset								
33-1	20-1	Set Up								
33-1	30	Shear Catch								
33-1	30-1	Set Up								
33-1	40	Draw								
33-1	50	Degrease								
33-1	50-1	Set Up								
33-1	60	Finish Strike								
33-1	60-1	Set Up								
33-1	70	Joint Blank								
33-1	70-1	Set Up								
33-1	80	First Curl								

FIG. 38.5. Combination time, inspection, and move ticket.

Thus the planning department need only order performance of an operation, and inspection and movement follow automatically. This situation gives the foreman somewhat more direction of the production process. In such cases proper modifications must be made in the checking of progress on the route sheet and the issuance of new job cards to the worker. Time must ordinarily be stamped on the time cards by the foreman or his representative in the shop, and new job cards must be

issued on the request of the foreman, as he sees that the worker is nearing the end of a job. This change is necessitated by the retention of the time ticket in the shop until after final inspection of the operation.



TIME TICKET

SCHEDULING DEPARTMENT

SHOP TRAVELER

RAW MATERIAL TAG

MATERIAL REQUISITION

OPERATION COMPLETION NOTICE

TOOL WITHDRAWAL

MATERIA[illegible]RAVELER

DEPARTMENT WORK ORDER

FINAL PART INSPECTION

PART NAME	LOT	QUAN.	START DATE	DUE DATE	JOB NO.	WORK ORDER NO.
Pivot Bearing 24950	1	500	6-10-43	6-30-43	7985	10007

MATERIAL	SPEC. NO.	CODE NO.	QUAN.	UNIT	TOTAL	RATE	COST
.156"-.001" Stn. Steel Type #416	9601	1704	2.6	lb			

PART NO.	OPR. NO.	DEPT. NO	MACHINE GROUP NO	TOTAL OPR. HOURS		START DATE	DUE DATE	PIECES GOOD	PIECES REJECT	INSPECTOR	DATE
24950	1	400			050	6-10-43	6-10-43				
24950	2	410			645	6-10-43	6-11-43				
24950	3	440			125	6-11-43	6-12-43				
24950	4	410	1269	12	500	6-14-43	6-15-43				
24950	5	410	1269	12	500	6-16-43	6-17-43				
24950	6	413	533	20	000	6-18-43	6-22-43				
24950	7	440			125	6-23-43	6-24-43				
24950	8	476		16	700	6-24-43	6-28-43				
24950	9	440			165	6-29-43	6-30-43				
24950	10	476		6	300	6-30-43	6-30-43				
DR											

DATE	QUAN SUBM'T'D	QUAN. ACCPT.	QUAN. REJ.	REJ. TAG NO	REASON FOR REJECT	INSPECTOR

DISPATCHER

Courtesy, A. B. Dick Company

Fig. 38.6. A master form. One stencil will run off all the forms used in production control. The different forms have the proper headings printed for all permanent data. The rest is placed on a stencil that will run as many copies as are needed for one order.

Preparing all tickets from one master. Figure 38.6 illustrates forms that are run from a stencil by the A. B. Dick Company. This same information is listed on each of the following tickets:

1. Scheduling department.
2. Department work order.
3. Tool withdrawal.
4. Material requisition.
5. Raw-material tag.

6. Material traveler.
7. Operation-completion notice.
8. Shop traveler.
9. Final inspection report.
10. Any other tickets or records that may be needed.

As many copies as are desired may be run. Each ticket contains the same information, but the ticket may also be drawn so that any additional information may be inserted at the appropriate time as the part moves from place to place. In many such operations great ingenuity has reduced the amount of clerical work required in making out production-control forms. This type of procedure not only saves time but also contributes to accuracy. If the original master copy is correctly prepared, all the other copies will be exact duplicates.

Strip operation tickets. Strip operation tickets are frequently used in plants having largely standardized operations. This does not mean that all items must be made alike but that there is a high degree of standardization in spite of the different sizes and types, as in the manufacture of men's clothing, shoes, hosiery, and many other items. Such a ticket is illustrated in Fig. 38.7. This ticket is assigned a number and attached to the batch of materials as it is about to start through a series of operations. It has a coupon for each operation in the series. As the worker performs an operation, he detaches a coupon; part of it he usually gives to his supervisor for transmission to the planning department, and part he retains for purposes of checking with his pay envelope. This portion of the coupon is necessary for the worker, since there is no direct check with him to insure that he has received credit for his work. He receives such credit only as a batch of tickets is turned into the planning department. If operations are short and must be performed in the same sequence, this gives all the necessary control for the planning department and at the same time allows the goods to flow through the factory promptly.

A number of different strip tickets can be provided for the whole sequence of operations, each ticket covering a controllable unit. The order of work can be maintained throughout the sequence of operations covered by one ticket, if the numbers on the tickets correspond with the order of work, and if the batch or lot of goods with the lowest serial number is put through each operation first. Manifestly, serial numbers can be changed at the end of each series of operations. Movement of material at the end of a series of operations must be made on separate order from the planning department, as under any other system. If inspection is necessary after operations, it is usually treated as one of the procedures covered by the strip ticket.

	ASS'T	SIZE	STYLE	OPER. NO.	QT.	AMOUNT
JOAN MILLER LABELS ½" Seams 3/4"U.Arm 2" blind hem bottom			9201	30	ODD	21849
Examine trim	21849		9201		U1	265
Turn	21849		9201		U2	030
Mark buttons	21849		9201		MK	.0300
Shank buttons on bck	21849		9201		S76	.0625
Hem bottom blind	21849		9201		Q3	.0700
P-set sleeves & close sides	21849		9201		P69	.1875
Topstitch set zipper	21849		9201		I5	.1875
Close side for zipper	21849		9201		I5A	.0450
Set yoke to frt Waist	21849		9201		K6	.1325
Set Neckline fcgs 30"	21849		9201		K2A	.1725
WAIST CONT'L			9201	30	ODD	21849
Join shoulders	21849		9201		K2	.0425
Pink Piece entire Bck Waist	21849		9201		K2B	.1825
Set 1 ops to Waist Bck	21849		9201		K1B	.0675
Piece entire frt waist	21849		9201		KI	.2225
SKIRT			9201	30	ODD	21849
Join W & S 40" Merrow	21849		9201		I69	.0950
Shirr top of skirt	21849		9201		I20	.0625
	21849					
YOKE			9201	30	ODD	21849
Merrow edge yoke seam	21849		9201		K69	.0375
Off Press yoke	21849		9201		KV1	
Turn fcgs by operator	21849		9201		K4	.0550
Piece Yoke fcgs 10"	21849		9201		KIA	.2875
SLEEVE			9201		ODD	21849
Hem sleeve 20" Blind	21849		9201		H3	.0675
Set bottom sleeve dar	21849		9201		H2	.1825
	21849					
	21849					
	21849					
FCGS			9201	30	ODD	21849
Piece Neckline fcgs	21849		9201		K3	.1625
	21849					
	21849					
	21849					
CRINOLINE			9201	30	ODD	21849
Merrow join Crinoline	21849		9201		HI	.0950
	21849					

Courtesy, A. B. Dick Company

FIG. 38.7. Strip operation ticket.

Planned control of filling orders in wholesale houses and mail-order houses. Probably the most complete planning control of work outside of manufacturing is required by the large wholesale houses and the mail-order houses. These organizations are similar in principle, although differing somewhat in detail.

Principles of motion economy and plant layout are used by the large mail-order houses, who employ industrial engineers to study operating conditions constantly. The mail-order houses estimate the volume of work for the day by weighing the incoming mail. Definite routes are followed by incoming orders. They are first opened by an envelope-slitting machine; they then move on a belt conveyor past readers who remove the contents, count the money, and place it in separate containers to go to the finance division. The orders then proceed to other clerks along the conveyor who read them and interpret items that may be confusing. These orders also pass by girls who price each item, and others who edit them for filling by the order-filling clerks. Copies are typed for each department which may have an item on the order. The shipping label is prepared in the central control office. All the required information is assembled by the central office and a group of orders called "blocks" is released at one time. These blocks may be of sufficient quantity to require a definite length of time to be filled, such as twenty minutes. Naturally the number of employees filling orders and the nature of the orders influence the number of orders in a block. All items for a given order, provided they are in stock, meet in the wrapping and shipping department, where they are assembled in one package if possible, weighed, routed as to parcel post, express, or freight, and started on their journeys to their buyers. The mail-order houses strive to ship every order within twenty-four hours after its receipt. This policy is adhered to with a high degree of performance. When it is recalled that literally thousands of orders, ranging from one thimble to linoleum, mattresses, and other large items, are handled daily, the magnitude of the task can be appreciated. Such performances are real tributes to the effectiveness of scientific management in the merchandising field.

Location of dispatch stations in the shop. In large plants that use central planning it is desirable to locate dispatch stations in the shop or to provide pneumatic tubes through which time tickets may be transmitted. Because of the expense of such tubes and the desirability of direct contact between the workman and the man who is handing him his job, the first alternative is usually adopted. Dispatch stations in the shop do not imply decentralized control; those in charge merely issue the tickets at the direction of the central planning department. Perhaps they have some control over movements of material. At any rate, in large

plants they save steps and time for the worker. To have the worker come to the window of the planning department for his new time ticket is possible only in small plants.

Decentralized production control. Decentralized control is frequently set up when the management desires to allow the foremen to retain a considerable share of the task of planning the work. It has already been indicated that the development of the master schedule and the routing between departments are functions which must be performed centrally. Portions of the other planning functions may be decentralized. Decentralized planning and dispatching are almost imperative in large plants.

Routing to machines is the planning function most frequently left to the planning supervisor of the department. If this function is given to him, of necessity much of the operation of the order of work will automatically go with it. If there is decentralized control, dispatching to the worker will always be done within the department. If routing is to be given to the planning supervisor of the shop, whether he is or is not under the control of the foreman, there are usually certain operations which must be routed centrally. An illustration is the situation existing when there are only two or three machines of a given type, yet several departments have work that has to be done on these machines. Under such circumstances central routing is desirable to prevent throwing the shop out of balance.

If there are departments which have large batteries of the same kind of machines, all capable of doing essentially the same kind of work, ideal conditions for decentralized routing are found, because the foreman or the planning supervisor of the shop is ordinarily in a much better position to determine the machine to which a particular job should go than is the central planning department. In such cases, the routing of material to the department, nearly always a function centrally performed, is in reality routing to a particular group of machines. The decentrally controlled routing takes on the nature of a dispatching function, which will indicate the machine of the group, which, from the standpoint of shop conditions, is best able to take on the particular operation. If routing of this nature is done decentrally, the central route sheets will ordinarily indicate only departments, not machines, and there will be no necessity of maintaining route sheets within the department.

The planning station in a department of a shop operating under decentralized control may maintain a planning board which is similar in almost every respect, including operation, to the central planning board, except that it covers only the machines and work places of the one department. If such boards are maintained departmentally, there is little or no need for the central board, which will be replaced by some sort of progress

chart indicating the operations to be performed, by departments, and the progress that has been made upon them.

Frequently in large departments there are two clerks, one collecting cost data and the other devoting his time to planning and controlling the production schedule. Both these functions are usually performed, even though the volume of work may justify only one clerk. If there is only one clerk, he will often report functionally both to the cost department and the planning department, even though he may be directly under the supervision of the department foreman.

Under decentralized control, movement of materials between departments may be ordered by the departmental planning unit, but after consultation, usually by telephone, with the central planning force. Movement of material from stores to the first department in which work is to be performed may or may not be ordered by the central department. If, under decentralized control, work is moved from a manufacturing department to a separate inspection cage, the department planning unit will usually order the work into the inspection cage, while the ordering of the work out of the inspection cage to the next department will frequently be left to the central planning group.

Decentralized planning and dispatching involve the same techniques and principles as centralized control. Decentralization is only a means of making the control run more smoothly. Nominally, the foreman is usually put in charge of the departmental planning under this arrangement. Nevertheless, the planning clerk in the department, who is theoretically supposed to report to the foreman, is usually given such complete control of planning by the foreman that he is, to all purposes, wholly a representative of the central planning department in the shop. In addition to correlating the work of the department with the central plans, he makes reports of progress on work under way, which enable the central department to post any records of progress which they may maintain. In any case, he is a force working toward flexibility in planning.

CHAPTER 39

PRODUCTION CONTROL IN MASS-PRODUCTION INDUSTRIES

Characteristics of mass-production planning and control. The fundamentals of production planning and control are the same in the small jobbing shop and in the large-scale enterprise. There are not so many changes in mass production as in a smaller enterprise; hence the procedures are simpler. In either case materials must be identified and accounted for, operations performed, labor costs accumulated, and inspections made. It is in the original development of the manufacturing process and in the layout of the machinery that the greatest problems arise.[1] Since the automotive industry has developed this type of production most completely, it has also worked out, to the greatest extent, production methods suited to the process.

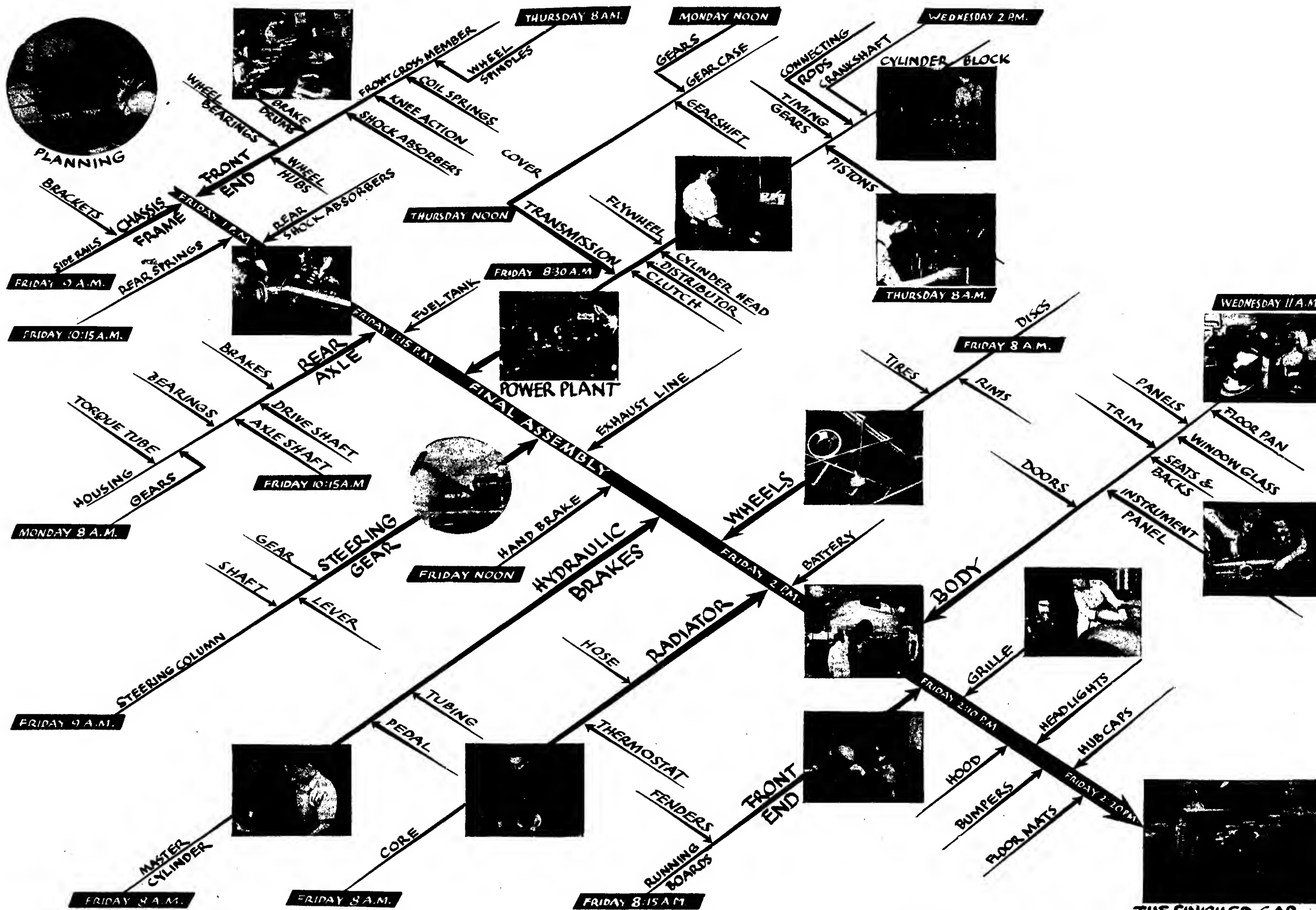
It should not be inferred that there are no changes in setups in the mass-production plant. In fact, the large plant may be conceived as an orderly arrangement of a series of smaller plants known as departments, the respective departments being the suppliers of other departments. Some of these departments manufacture parts, but not in quantities to keep the machines constantly in use. These machines are changed from time to time. Other machines perform only one type of work for as long as one year.

An illustration of large-quantity manufacturing.[2] The automobile industry has led the field in plant layout, use of conveyors, flexibility in certain details of a standard product, use of special-purpose mass-production equipment, and application of Taylor's principle of high wages and low unit costs. Other industries, such as farm-implement manufacture, steel manufacture, electrical manufacture, and clothing manufacture, have adapted the mass-production techniques of the automobile industry to the individual requirements of their respective enterprises.

Figure 39.1 does not represent a single automobile manufacturer's method of control and synchronized time schedule but is a composite of several. Individual plants may exceed the remarkable performance indicated on this chart.

[1] See Fig. 12.10, p. 175.

[2] Adapted with permission from *Automobile Facts,* Vol. II, No. 4, December, 1939.



"Automobile Facts," Vol. II, No. 4, Automobile Manufacturers Association

FIG. 39.1. Composite production scheduling and route chart.

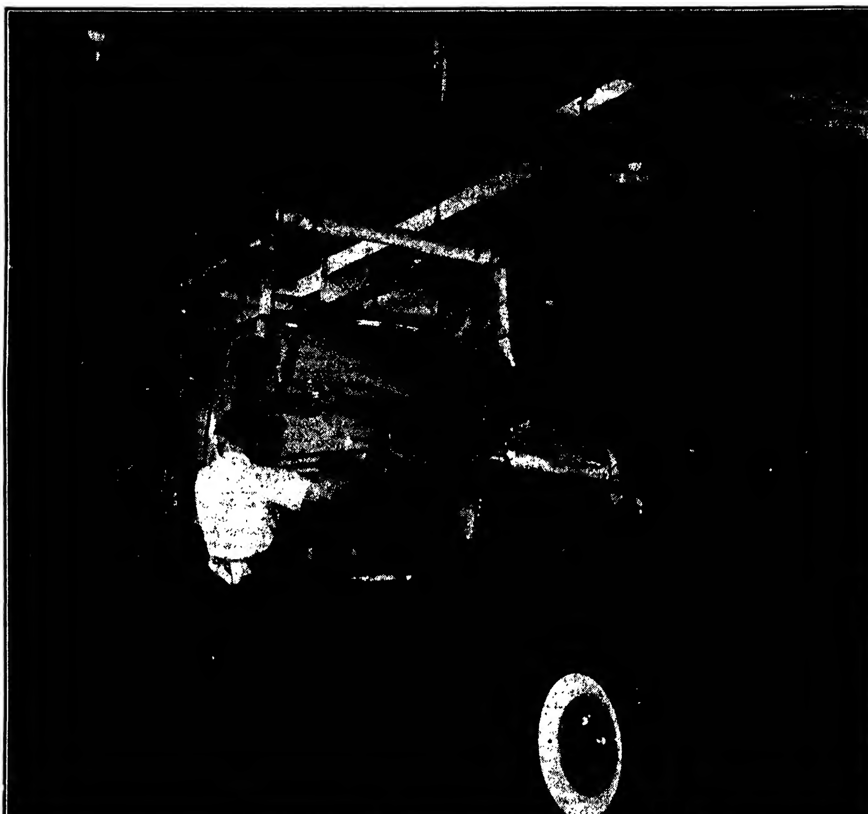
One large plant schedules a finished car to come off its assembly line every three minutes. This plant also has several assembly plants in various parts of the United States. If the volume in one area requires a finished car in two minutes, an additional assembly line or an additional shift can meet the increased need. To achieve such production careful timing of each of more than 15,800 parts, subassemblies, and raw materials is required. Hundreds of freight cars and trucks are unloaded and loaded daily, so that adequate loading and unloading docks, as well as material-handling equipment, are needed (see Fig. 13.4, p. 185). Many purchased parts and assemblies go to the assembly line directly from their outside supplier and must meet a time schedule, just as do the parts produced by the plant itself.

The completed automobile is largely an assembly of a series of subassemblies put together in an orderly sequence. The frame comes to the final assembly line from another department or even from a plant miles away, as do the body, steering wheel, wheels, fenders, tires, and engine. As the frame proceeds down the assembly line, brackets are attached, to be followed in turn by the front axle assembly; rear springs; rear shock absorbers; rear axle assembly, including brakes, drive shaft, etc.; fuel tank; power plant; steering gear; exhaust line; hand brake; hydraulic brakes; wheel assemblies, including tires; radiator; battery; body (see Fig. 39.2); fenders, front end, and running boards; hood; headlights; bumpers; hub-caps; and floor mats. Before the end of the assembly line is reached, gasoline is placed in the tank, and the car is driven off the line under its own power. Each of these assemblies was started in time to be ready when needed on the assembly line. The entire process represents the "flow" type of production. Scheduling is keyed to make this possible. Some of the material that goes into the assemblies is produced months ahead of actual use in the final product. Orders are anticipated, so that malleable iron parts are cast as long as thirty or even ninety days in advance, gear blanks are machined, upholstery is woven and dyed, tires, tubes, and rims manufactured, etc., so that a dealer's order for a particular model with a specified color and trim combination may be filled in a reasonably short time, usually from one to two weeks.

Scheduling quantity production. The master schedule in such manufacturing is very simple, merely a sheet of paper showing the number of each type of automobile to be made in a given month or months. This master schedule is broken up into components by the production department. If 1000 automobiles are to be made in a given month, 1000 crankshafts, but 5000 wheels, will be needed.[3] Presumably there will be a

[3] Most of the present models have a spare wheel.

sufficient amount of each type of equipment in the factory to make the relative numbers of each part that is to be manufactured within the plant. The planning department must see that the schedule does not call for larger amounts than the capacity of the equipment or assembly lines



Courtesy, General Motors Corporation, Pontiac Motor Division

Fig. 39.2. Lowering a body to meet the chassis at the Pontiac Motor Company plant, Pontiac, Michigan.

can produce. If this should happen, the general management must decide whether additional capital is to be invested in equipment to meet the increased load, or whether the emergency is to be met by overtime, an additional shift, or letting out more parts to be made on the outside.

The purchasing department and the materials department are given copies of the schedule broken down into components. This is the necessary authority to purchase in quantities sufficient to cover the schedule. No maximum, minimum, or apportioned amount is necessary, as each

series of purchases just covers a particular production schedule, with proper allowance for material spoiled in manufacture.

The schedule is broken up according to the time that components and operations on them must be started, in order that assembly lines may have all components as needed. Daily quotas for each component are then set, these bearing a direct relation to the master schedule. In many plants deliveries are arranged so that only two or three days' supply of any purchased material or component is on hand at a time. Manufacturing operations on components are laid out in the same manner. This procedure reduces to a minimum the amount of capital tied up in materials, and it also reduces the amount of storage space needed.

Schedule for an automobile-body manufacturer. Changes in the design of the product and in the processing frequently require a revision in manufacturing time or a readjustment in plant layout, and at times result in excess manufacturing space or a need for additional floor space. The introduction of the all-steel body has almost eliminated the woodworking departments, the large dry kilns, and the large lumber-storage space. The substitution of steel for wood has reduced the length of the production cycle. In 1928 the length of time ahead of body-delivery date required to authorize the ordering of lumber was 158 working days, 30

TABLE 39.1

TIME-DISTRIBUTION SCHEDULE FOR AUTOMOBILE-BODY MATERIAL

Material	Placing Order with Supplier (days)	Release of Detail Specifications (days)	Delivery to Plant before Use (days)	Processing Time before Assembly (days)
Sheet steel	90	With order	30	10–30 *
Malleable castings	42	With order	10–30 †	3
Upholstery	90–180 ‡	60	30	10–30 §
Lacquer	30	14	10–30 †	0
Glass	60	With order	10–30 †	0

* Fabrication of the steel panels used in the construction of a uni-steel turret-top body requires from 10 to 30 days, depending upon transportation facilities and the proximity of the manufacturing and the assembly plants. One complete set of stampings demands the use of some 600 dies, which are rotated in the presses. Thirty days are required to complete a set of body stampings because of the use of similar die cycles in press-room operations.

† The bank of material carried in stock ahead of processing depends largely upon the distance of the source of supply from the plant using the material. Lacquer and glass come ready for use and require no lag between the time of receipt and use.

‡ The variation in time is dependent upon the general situation in the wool market.

§ Preparation of the interior trim for a single body takes from 10 to 30 days of elapsed time. The material must be inspected, graded, matched, cut, and sewed.

days longer than for any other single item used in the body. In 1940 approximately 11 hours were required for the final assembly of a body, that is, from the time it first took form in the "setup buck" until it left the paint and trim departments. This total assembly time did not include the time involved in subassembly operations. The time-distribution schedule in Table 39.1 is a composite of the times required by a large automobile-body manufacturer for various phases of his 1940 production.[4] It is representative not of a single model but of the entire line.

Planned control in shipping. Adequate control of shipping requires careful planning and scheduling, particularly for wholesale houses and industries that ship in less than carload lots. In the meat-packing industry many dealers are not equipped to handle carload shipments. The large packer is faced with two problems that require close control. One is that excess labor and equipment will be needed if shipments are not synchronized with a definite schedule. The second problem is one of service. The dealers want delivery to coincide with their sales needs. Increased use of the practice of "mixed car shipments"[5] caused a difficulty to arise at a mid-western meat-packing plant that the management thought could be solved only by increasing its shipping facilities. An outside firm of consultants was called in to make a survey. The survey revealed that a proper system of scheduling would eliminate the necessity for additional loading stations and would give better service to the customers. After more than ten years of actual service the planned control of shipments is still working satisfactorily, and there has been no further consideration of enlarging the shipping facilities.

A large wholesaler in the Midwest had exactly the same experience as the meat packer. Another wholesale house had difficulty in making deliveries as promptly as customers desired. A careful analysis of practices and a revision of scheduling improved deliveries and reduced freight costs. It must always be kept in mind that a particular planning and control program is not static but must be adjusted to meet changing conditions.

Control of materials in mass production. In mass production delivery dates for incoming materials for a given order may extend over some time, and consequently but little paper work is necessary in handling stores in such plants. Follow-up of purchasing is responsible for seeing that materials are delivered in time to meet schedules. It will be recalled that

[4] This date is used, because, as our book goes to press, abnormal hold-ups due to material shortages still prevail.

[5] See Fred E. Clark and Carrie Patton Clark, *Principles of Marketing,* The Macmillan Company, New York, 1942, pp. 438–441.

the purchasing department is frequently given a copy of the schedule with material requirements. If this is not done, the production-control department places requisitions with the purchasing department for the material needed.

Professor Charles B. Gordy of the University of Michigan has pointed out:

> Stock records can be arranged in a manner that will facilitate greatly the follow-up. The issuing of a requisition for each batch of material leaving the storeroom results in too much clerical detail, in the case of the larger part of material used in assembling an automobile. Material can be charged from the stock records on the basis of the number of cars or units produced during a week or month, by breaking up this amount of production into the component parts of a complete unit. Certain companies have gone a step farther, and disburse stock on the basis of the manufacturing schedule in advance of building. This gives the follow-up department a knowledge of any shortage existing at the beginning of the month and gives sufficient time in which to expedite deliveries.[6]

A substantial amount of incoming material, such as batteries, tires, and wheels, is delivered to an area adjacent to the place these parts are assembled or placed in production. The layout of such plants should be so arranged that there need be relatively little finished-parts storage. The equipment should be balanced so that exactly enough parts will be produced daily for assembly requirements, and these parts should have the last operation performed on them so that they are available immediately for assembly, being finished either adjacent to the point of an assembly line at which they are used or near a conveyor which takes them to that point. Of course, this ideal cannot be reached exactly, and it is often desirable to have some finished parts banked near the point of usage to guard against temporary breakdowns.

Functions of the production-planning and control department in mass production. Production control requires less detail in the issuance of move orders and other paper work in mass production than in small-scale diversified manufacturing. In quantity production its functions are mainly to work up the schedules, to tell the various department foremen how many units they will be required to make in a specified time, and to maintain records to insure that the schedules are being followed.

As in any planning department, time study and material control may not come under the direction of production control. It is not necessary, because of direct line layout, to control work between machines to any considerable degree. It is obvious that, on account of the similarity of

[6] *The Journal of the Society of Automotive Engineers,* Vol. XVI, No. 6, p. 607.

the work put through the plant for a long period of time, the planning department is only breaking down into units the major business budget. However, with the advent of many color combinations in the automobile industry, planning—especially the dispatching function—has become immeasurably more complicated, even though the individual assemblies are still relatively simple to control.

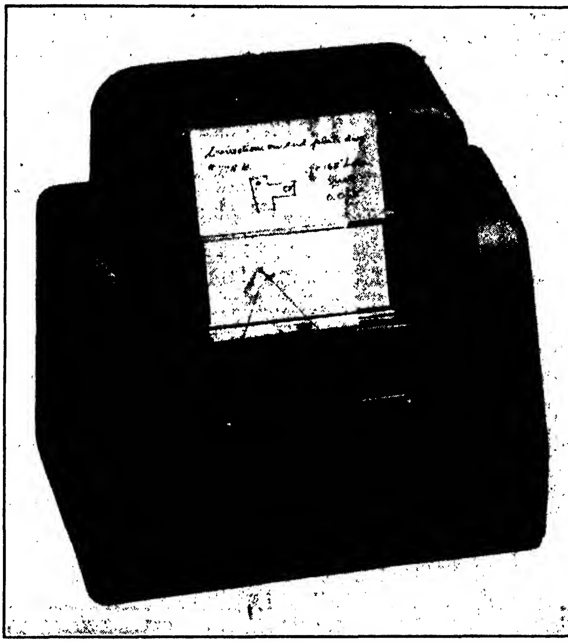
Courtesy, the Chrysler Corporation

FIG. 39.3. Dispatcher's office, Plymouth Motor Car Company, Detroit.

Figure 39.3 illustrates the functioning of a dispatcher's office and the intricacies of control in the Plymouth plant. Through the telautograph (Fig. 39.4) and the "track sheet," instructions are given to some sixty key points scattered throughout the plant. For each car built specific instructions regarding color, type of upholstery, and kind of equipment are issued on a track sheet. From this track sheet each department interested can tell the exact order in which certain chassis are moving down the assembly line and is thus in a position to load its conveyor with the proper parts to go with each particular car. When a body is released

to the body-finishing and inspection line, this is a signal to order all other parts to match the body, and instructions are issued accordingly. It is said that only once in eleven years has a wrong-colored chassis arrived at the "body drop" (see Fig. 39.2) in the Plymouth plant.

Only a few types of manufacture can be put on a quantity basis such as that just described. This type of production is possible only when



Courtesy, Telautograph Corporation

FIG. 39.4. The telautograph, an instrument widely used in production control in large-scale manufacturing. It is used also in receiving and reporting the results of laboratory tests of material in process.

manufacturing a relatively few standard items for which there is a large demand. It will be evident that such a system is profitable, not only because direct production costs are lower, but also because the costs of production control, when the volume involved is considered, are much less than in diversified manufacture.

It must be remembered that large-scale production is possible without the high degree of "flow" type of production used in the conveyorized automobile plants. For instance, shoe manufacturing is large-scale, yet there are literally hundreds of sizes and types of shoes. Naturally each industry has to modify its processes of manufacturing and production control to meet its particular needs.

PART IX

PERSONNEL ADMINISTRATION AND MANAGEMENT (INDUSTRIAL RELATIONS)

CHAPTER 40

THE ORGANIZATION AND POLICIES OF THE PERSONNEL DIVISION

The personnel function in an organization. Personnel relationships comprise the primary concern of a personnel division. Regardless of the size of the enterprise, such relationships exist. In the small firm these contacts are on an intimate basis and frequently are informal. If it were possible to retain the same interest in the supervisory force in the enterprise as it grows, many of the personnel problems of large industry would never arise. Personal contacts with top management are impossible for most employees in a large corporation. This situation leaves a void that has to be compensated for in some manner. The personnel division strives to get each supervisor to be to his men what the owner was when the enterprise was small and tries to fill in the gaps where the supervisor cannot meet the situation fully.

The objective of *personnel management, personnel administration,* or *industrial relations* in an organization is to attain maximum individual development, desirable working relationships between employers and employees and between groups of employees, and effective moulding of human resources as contrasted with physical resources.[1] In order that specialized skills may be brought to the solution of personnel problems, the personnel division has been emerging during the past thirty-five years.

Many a sound personnel policy formulated by major executives would scarcely be recognized by these executives if they saw its transformation in the process of being passed down the line organization. In all discussions of personnel relations it should ever be kept in mind that the *most effective personnel relationships are those which grow naturally out*

[1] This statement of the objective was formulated by a small group of members of the American Management Association during an informal discussion of personnel problems.

of the work situation, and that the personnel department's major function is to promote a harmonious environment for the worker. Swell!

The personnel department is that section of an organization that can continuously look at operations from the viewpoint of the worker. And, regardless of its own particular method of organization, this is its primary reason for being. The organization of a personnel department does not imply that line executives may cease to think of the workers' point of view. It merely means that there is in the organization a department which will now continually bring the workers' point of view to the line executives. Neither does the creation of a personnel department relieve the general management of the necessity of considering major policies with the workers' point of view in mind. *No personnel policy will succeed which does not have the original and continuous backing of the general management.* It is the function of the personnel manager to keep the general management in constant touch with the attitudes of the workers and to guide management toward decisions which will evoke the whole-hearted cooperation of the workers. It is a task of the personnel department to prove to the worker that he is not a cog in the machinery of production, but rather a vital section of the machine, regardless of how small his share in the productive process may seem to be.

The most effective way in which the personnel manager and his department may assure the worker of their interest, and that of the firm as a whole, in his problems is an intangible one. It rests largely on their general attitude. To secure the cooperation of the workers on the basis of such an attitude is a gradual achievement and one that is gained through effective handling of particular situations. There are many ways for a personnel department to work toward this aim, but, regardless of particular means which may be described, the most effective methods will occur to the personnel staff at particular times and under particular conditions. One primary step is to provide for the hearing of any complaints concerning wages, treatment, or conditions, to investigate these complaints, and, if valid, to endeavor immediately to adjust them and prevent their recurrence. Although it is fundamental that the personnel department shall thoroughly understand and be sympathetic with the employee, in this relationship they must not forget their obligations to the production forces nor the requirements of production.

Organization of the personnel division. The industrial-relations activities, as has been pointed out, by no means replace the responsibilities of the line executives, but merely supplement them. *Personnel management is management,* not a substitute for management. The industrial-relations department is a staff department as far as the entire organizational structure is concerned.

The various functions of the industrial-relations division may be classified as follows:

1. Maintenance of an adequate labor supply (employment).
   - 1.1. Selection and placement.
   - 1.2. Follow-up of the new employee for initial adjustment.
   - 1.3. Promotion and transfer.
   - 1.4. Layoffs, discharges, rehiring, and retiring.
   - 1.5. Records and research.
2. Education and training.
   - 2.1. Introduction of the worker to the company's policies and to his department supervisor.
   - 2.2. Job instruction—apprentice training, vestibule schools, instruction on the job, etc.
   - 2.3. Foreman and executive training.
   - 2.4. Special training programs for college graduates and other selected employees.
   - 2.5. Preparation of special annual report designed to provide information desired by employees.
   - 2.6. General industrial education.
   - 2.7. House organ and library facilities.
3. Maintenance of satisfactory personal contacts and employee relationships.
   - 3.1. Job analysis, specifications, and rating.
   - 3.2. Employee ratings.
   - 3.3. Wages and rewards.
   - 3.4. Shop rules and regulations.
   - 3.5. Labor audit.
   - 3.6. Employee records and labor statistics.
   - 3.7. Regularization of employment.
   - 3.8. Adjustment of individual grievances.
   - 3.9. Labor turnover.
   - 3.10. Suggestion systems.
4. Maintenance of satisfactory group relationships.
   - 4.1. Contacts with employees' representatives.
   - 4.2. Contacts with employers' groups.
   - 4.3. Contacts with governmental agencies.
   - 4.4. Contacts with community agencies.
5. Maintenance of employees' health.
   - 5.1. Initial physical examination and periodic examinations.
   - 5.2. Treatment for minor injuries and diseases.
   - 5.3. Hospitalization.
   - 5.4. Sanitation, health education, and mental hygiene.
   - 5.5. Rest periods, recreation, and general counsel.
6. Maintenance of a safe place to work.
   - 6.1. Safety guards and inspection of equipment.
   - 6.2. Safety programs and educational activities.
   - 6.3. Fire protection and police activities.
   - 6.4. Safety records and workmen's compensation for injuries.
7. Service activities (sometimes erroneously called "welfare work").
   - 7.1. Credit unions, savings and investment plans.

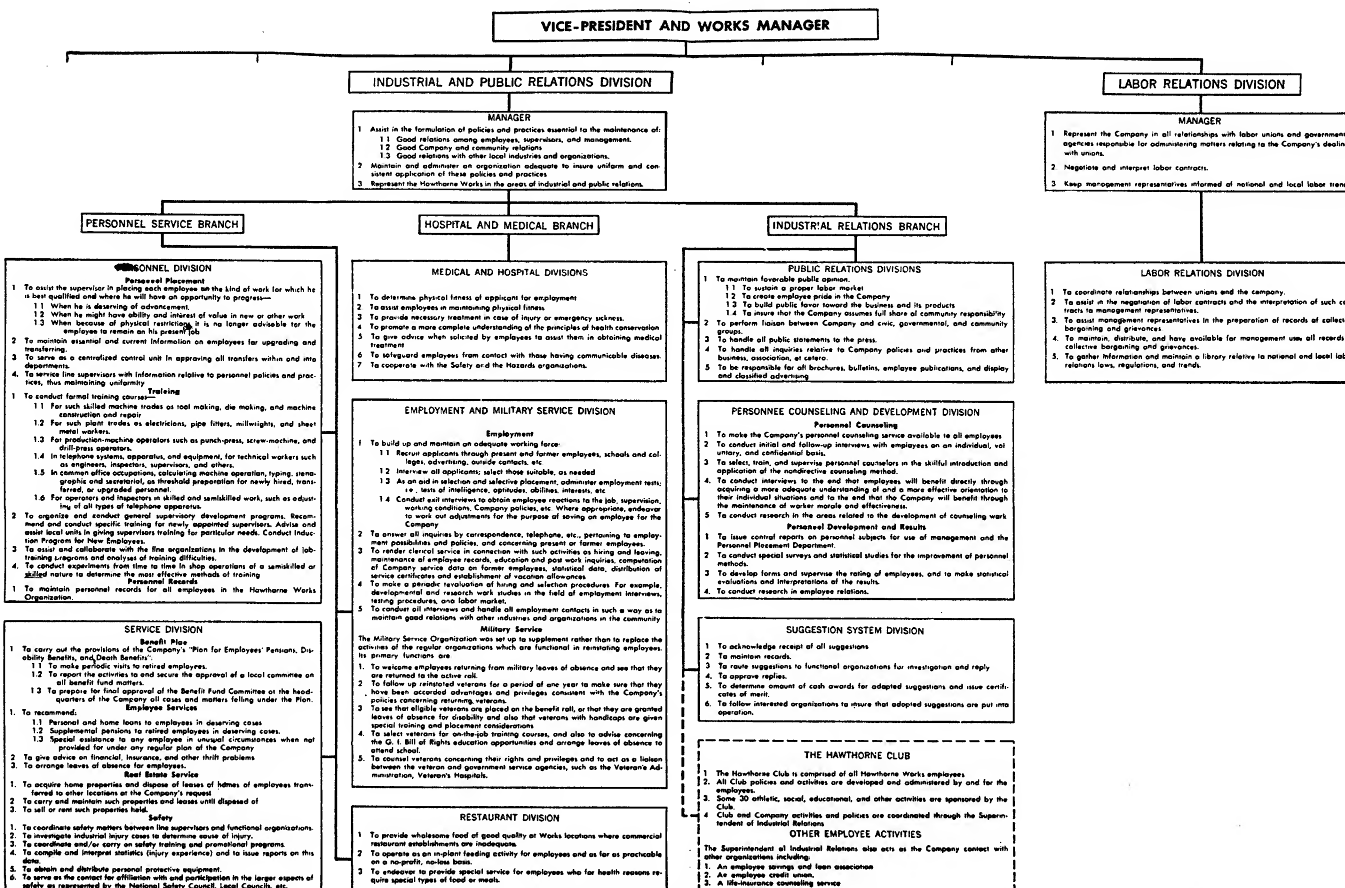


Fig. 40.1. Organization's chart of the Industrial and Public Relations Division, Western Electric Company, Hawthorne Works, Chicago.

7.2. Social and recreational activities.
7.3. Housing programs.
7.4. Company stores, restaurants, etc.
7.5. Advisory services, legal aid, hospitalization programs for employees' families, etc.

The size of the business enterprise will influence to a great extent the actual physical organization of the industrial-relations division. In a small enterprise many of the functions listed above will be combined in the same person. In a very small business these functions may be carried on by the plant superintendent, secretary, treasurer, chief clerk, or some other person. In a large organization use is frequently made of the Advisory Committee on Industrial Relations. Under such an organization the director of industrial relations usually acts as the secretary or chairman of this committee.

Figure 40.1 shows the organization of industrial relations at the Hawthorne Works of the Western Electric Company, Inc. There are three main divisions: placement, research, and employee service. This chart is so complete that it requires little comment other than to say that this organization is an outstanding leader in personnel research.

Personnel policies. A personnel policy may be defined *as the body of principles and rules of conduct that governs* the business enterprise in its relationship with its employees. Such principles and rules are a fundamental part of the basic business policies that guide the organization in the achievement of its major objectives. The more clearly these major objectives are outlined, the more specific will be the personnel policies, both in statement and operation. Personnel policies, like business policies in general, are dynamic, changing to meet the current situation. Although they are dynamic to meet fundamental changes, they nevertheless should possess a large measure of stability.

The sound personnel policy avoids opportunism and is essentially stable, having due regard for the human equation. In the long run, personnel policies will not be sound unless the organization policies are likewise sound. A successful business enterprise possesses organic unity of purpose. A defect in any function weakens the entire organization. The objectives of an enterprise are naturally influenced by many considerations: competition, tradition in the particular industry, technological development, social approval, the prevailing attitude of labor, governmental controls, and the ideals of the entrepreneurs. In the light of our present business mores a sound personnel policy should, in general, possess the following characteristics:

1. It should recognize individual differences in capacities, interests, ambitions, emotional reactions, desire for security.

2. It should recognize the current trend toward group action and a tendency to seek a voice in those phases of management in which the worker is vitally interested. (Management should not be blinded by collective bargaining to the fact that individual differences are important. A worker or a group of workers may feel as lost in a large union as if they had no formal recognition whatever.)

3. It should be definite. Ambiguity and uncertainty are destructive of plant morale.

4. It should be stable yet possess sufficient flexibility to meet changing conditions and the varying needs of individuals.

5. It should be an integrated part of other basic company policies. The lack of organic unity results in confusion.

6. It should provide adequate means for becoming generally known and understood by all persons concerned.

7. It should give due regard to the interests of all persons: the workers, the consumers, the public, and the owners of the capital.

The extent and nature of personnel policies. The nature and the extent of personnel policies vary with the individual enterprise. Some activities are basically of a personnel nature and yet for organization reasons are classified under other than personnel departments. There is usually a personnel policy, either in writing or informally understood, covering every item listed under the tabulation of functions of the industrial-relations division.[2]

Interpreting company policies to the employees. Sound policies promulgated by management or formulated cooperatively with representatives of the employees will function smoothly for the most part in proportion to their understanding and acceptance by the rank-and-file workers and their immediate supervisors. When the organization is relatively small, these policies can be readily communicated in person or by the use of the bulletin board. The actual practices and acquired rights of interested parties become accepted customs and later traditions. Even under these simple conditions the problem of initiating new employees into the organization remains difficult. With the growth in the size of organizations the problem of mutual understanding of personnel policies becomes increasingly greater.

To facilitate the transmission of personnel policies to interested persons, to avoid misinterpretations as far as possible, and to lend increased stability to these policies, many corporations publish a statement of their programs. For the past twenty years this practice has been gaining in acceptance. A few of the many outstanding companies that have published statements of their personnel policies are the General Motors Corporation, the American Rolling Mill Company, the Socony-Vacuum

[2] See Scott, Clothier, Mathewson, and Spriegel, *Personnel Management,* McGraw-Hill Book Company, New York, 1941, pp. 30–32, for a detailed tabulation of the activities and functions of a personnel division.

Oil Company, Inc., the Procter and Gamble Company, Marshall Field and Company, and the International Harvester Corporation.

How large must a business enterprise be to justify a separate officer responsible for personnel relations? There is no unanimity of opinion regarding the number of workers that will justify the employment of a full-time personnel director.[3] Some early writers on the subject stated that an organization should have from 800 to 1000 employees to justify this functionalization. Today there is usually a separate personnel department in most companies employing 250 or more persons. Although the personnel function exists in any company, it is likely not to be formalized in a company of fewer than 200 people but to be handled by the respective department heads or some other person in connection with his other duties. Recent trends in labor legislation have added to the work that must be done by some agency of the business. In smaller organizations this burden may well be assumed by the personnel officer, thus justifying the employment of a full-time man in an enterprise that otherwise might believe his services an unnecessary expense.

The position of the company in the life of the employee. Paternalistic concepts of the employer-employee relationship cannot help but destroy morale, and yet the personnel department must stand ready to cooperate with any outside interests, municipal or private, which may be taking steps toward general improvement of social conditions within the community. It is a peculiar fact that the more the personnel department works with problems of morale development,[4] the more likely it is to extend into paths and methods of activity which lead in the direction of paternalism. The type of work within the plant and within the community which has the greatest possibilities for the development of industrial good will has also the greatest possibilities of paternalism if not founded upon a sound economic, sociological, and psychological basis. The employer must ever be on the alert to avoid acts of normal human sympathy which will later react unfortunately. The same end can usually be attained, although possibly with less dispatch, by working through the employees rather than by direct action on the part of the employer.

Some plants, located in communities which are unable to provide amusement for their citizens because of their smallness or remoteness,

[3] The terms "industrial-relations department" and "personnel department" are used interchangeably in industry. In the merchandising field the accepted term is more frequently "personnel department."

[4] Factually plant morale is a by-product of satisfactory relationships of the employee in his work unit. Many attempts at morale development defeat their own objectives by making the desired end too obvious.

frequently find it necessary to provide living and recreational facilities for their employees in a manner which may smack of paternalism. This practice may not prove pernicious, provided it is properly handled. What must be avoided are plans indicating that the company feels it controls the entire life of the worker, merely because it is his employer.

Critics of misguided yet sincere efforts of employers in the past to serve their employees often underestimate the influence of the company in the lives of its employees. In this connection it is well to interpret what is meant by the term "company." As a legal concept it exerts very little, if any, tangible social influence upon the worker with the possible exception of its being a symbol of ownership of the property. In this sense the right in property is frequently held very lightly. To steal or pilfer from a corporation usually does not bring down upon the worker the same social disapproval as stealing from an individual. The company as represented by the officials is real to the workers in just about the same ratio as their personal contacts with these officials. Usually the "boss" is the management, as far as the individual worker is concerned. The company as a group of persons working toward an objective of producing a given product is in a very real sense a vital social as well as economic organization. The effective unit is usually the departmental organization, as far as social influence is concerned.

There is both an official and an unofficial organization. The official organization is represented by the managerial controls, whereas the unofficial organization consists of the voluntary social structures that naturally take shape when groups of people are thrown into intimate contact with each other. The personal satisfactions derived from membership in the business group are determined in part by the degree of homogeneity of its membership. Not infrequently there may be several groups within a department, based somewhat upon race, religion, fraternal affiliations, age, sex. Unless the social prejudices are too strong, however, the social group will cut across many barriers to draw individuals with like tendencies together. It is very common indeed, particularly among people of the same general age group, to find the social lives of the members of a work group intimately interwoven. This is especially true in the smaller cities, but the same tendency exists in the city of Chicago.[5] The company, in the sense of those collectively employed under a given management, bulks large in the lives of the employees, who use the term "we" when relating their activities together.

[5] See R. J. Roethlisberger and William J. Dickson, *Management and the Worker*, Harvard University Press, Cambridge, 1940, for a comprehensive study of the social structure of the work group and the influence of morale upon productivity.

The size of the personnel staff. In studying the various personnel programs analysts frequently try to establish a ratio of personnel employees to other employees. Such a ratio is practically meaningless, since companies vary markedly in the organizational structure within the personnel department. For instance, one company includes the safety and sanitation division, the cafeteria, plant protection and watch service, medical service and first aid, job evaluation and wage administration, and payroll departments in the personnel division along with the other activities that are normally included. Medical service and first aid logically belong in the personnel division, but they are found at times as a separate department reporting to a major executive. Even when the same activities are carried on in two personnel departments, the ratio of personnel workers to other employees is not necessarily the same in both for the simple reason that in one plant the program may be more extensive or more employee cooperation may be used. An elaborate recreational program may be entirely in the hands of the employees in one plant and largely company-sponsored in another. In one plant the medical program may be limited to an initial physical examination and first aid, whereas in a second plant periodic examinations, X-rays, and a complete medical program are conducted.[6]

[6] See National Industrial Conference Board, Incorporated, "Organization of Personnel Administration," *Studies in Personnel Policy, No. 73,* New York, 1946, p. 86.

CHAPTER 41

THE ORGANIZATION AND FUNCTION OF THE EMPLOYMENT DEPARTMENT

The function of the employment department. Historically the employment department was the first segment of the personnel division to be developed. In fact, even today in a substantial number of companies the entire personnel division consists of the employment department. The prime function of the employment department is to maintain an adequate supply of qualified workers. In the performance of this function the following activities are engaged in:

1. Maintain an adequate source of supply.
2. Secure information regarding prevailing community rates.
3. Develop job specifications.
4. Actually select new employees through:
   4.1. The application blank.
   4.2. The interview.
   4.3. Tests.
   4.4. Physical examinations.
   4.5. The checking of references, records, and the approval of supervisors.
5. Introduce the worker to the company's policies and to his department supervisor.
6. Follow-up the new employee for initial adjustment.
7. Maintain records of all employees hired, resigned, transferred, laid off, or discharged.

Centralization of employment work for the production forces can be justified on the following grounds:

1. Although the foreman may have much knowledge of the detailed requirements of jobs, his experience and the time that he is able to devote to hiring men are not usually sufficient to make him expert in the selection of workers.

2. The foremen cannot be expected to develop outside contacts for sources of labor in the way that a centralized department can.

3. Individual foremen are not in a position to perceive the needs of the plant as a whole, and thus the centralized department is better able to achieve the uniformity in selection which makes for a generally high character of personnel and *esprit de corps,* to place an applicant in the department for which he is best suited, to arrange in merited cases for a transfer of workers, and to prevent undesirable former employees from being rehired.

4. If centralization of employment of the production forces is once achieved, it is likely that the same policy will be shortly extended to all other departments of the business.

5. Specialization in the employment function is merely an extension of the principles of scientific management to one phase of personnel management.

Qualifications of the personnel in the employment department. The employment manager should be a man of broad vision and winning personality. He must be able to gain the confidence, sympathy, and appreciation not only of the rank-and-file employees but also of the heads of departments. In order to build up this rapport the employment manager frequently is forced to keep his eye on long-run policies rather than on individual cases in which he may differ from the department head. Under this policy, with the development of a well-run employment office, the number of selections made by the employment department but rejected in the operating department will be very small indeed.

To promote soundness of selection, it is essential that the employment manager, his assistant, or whoever else interviews applicants shall have a first-hand knowledge of the requirements of jobs. Thus, an interviewer of applicants for workers in the shop should have shop experience, even if it was acquired as a special student in preparation for his work in the employment office. No matter how complete the employment department's record of jobs, there is no substitute for first-hand knowledge. In addition to these qualifications, it is, of course, essential that the interviewer be especially qualified in the *power of analysis* and in *knowledge of human nature,* and that he possess a *constructive imagination.*

In selecting workers the employment department must fill requisitions submitted to it by the operating departments. These requisitions may be developed in conference at the time that some production or expansion program is decided upon, or they may take the form of routine requisitions made out on specified forms and submitted by the departmental heads from time to time as necessity dictates. The cause of the vacancy should be indicated on the requisition, so that the employment department will have a written record from the production departments of its shortcomings in filling jobs. The requisition should reach the employment department as far in advance of requirements as is practicable.

Use of job specifications. The employment department is greatly assisted in its operations if it has developed a set of specifications for all jobs for which it is called upon to supply workers. These specifications are of particular value in large organizations, where it is impossible for the employment manager or the interviewer to keep in mind the conditions of work of all jobs. In smaller organizations, it is possible for the

employment department to have a more complete and accurate knowledge of the jobs than anything likely to be developed on paper. Much information for job specifications can be secured from the methods department or whoever has control of the taking of job studies. The employment manager should be familiar with the job descriptions used by the methods department. In formulating job specifications for his purposes, however, the employment interviewer frequently needs some information of another kind and must also translate for his purposes much of the data on the job-study observation sheets. Job specifications should not be too elaborate. A tendency to gather a mass of detailed information which it is impracticable to utilize is likely to develop. The job specification of the personnel department is not so detailed as that used by the methods engineer.

The job specification should include only those qualities and abilities that will aid the employment officer in selecting the right person for the particular job.[1] Particularly when business conditions are good, it is impracticable to try to fit workers too closely to the job at hand. Even the most routine job, whether in the office, in the service department, or in manufacturing, is often transformed by the person who holds it. Although this statement does not mean that every attempt should not be made by the employment department to find workers who approximate the ideal for a given task, it does mean that a *new employee should be first of all an organization person,* with some chance of fitting in with the group in the department in which he will work, and, *secondly, should have general qualifications for performing a certain type of task, rather than be theoretically a perfect specimen to fit the particular niche that is vacant.* Business is dynamic, not static; and, if the employee fits one small niche too well, we are likely to find him fitting the original niche after the job has changed entirely through the interplay of new forces or new ideas in the business.

Effective job specifications aid, not only in the selection of the employee, but also in his transfer and promotion. If they are intelligently utilized by the employment department, they aid in preventing the overselling of a job to a prospective employee, with the result that he leaves within a few weeks after hiring. The specifications should include a consideration of minimum, rather than maximum, qualifications of the employee and a full statement of the conditions under which the work is

[1] See Scott, Clothier, Mathewson, and Spriegel, *Personnel Management,* McGraw-Hill Book Company, New York, 1941, Chapter XX, "Job Analysis, Classification, and Rating" for a definition of terms. The job specification refers to the requirements sought in the worker, and the job description covers the job itself.

done, in order that the interviewer's memory may be refreshed when he is seeking a person for a job; they should indicate the pay and the lines of promotion which seem to be open for the job (see Fig. 41.1).

Sources of labor supply.[2] For convenience the sources of the labor supply may well be classified under two general headings, *those within the organization* and *outside sources,* as follows:

1. Those within the organization.
   1.1. Transfer.
   1.2. Promotion.

1	2	3	4	5	6	7	8	9	10

JOB NAME — THE AMERICAN PULLEY CO. — JOB SPECIFICATION

1. GENERAL

DEPARTMENT — SYMBOL

2. MINIMUM QUALIFICATIONS OF OPERATOR

☐ MALE ☐ FEMALE — ENGLISH ☐ READ ☐ WRITE ☐ SPEAK — SCHOOLING ☐ COMMON ☐ HIGH 1 2 3 4 — NATIONALITY PREFERRED — FROM AGE TO — SIZE ☐ TALL ☐ SHORT ☐ HEAVY ☐ MEDIUM

TRADE EXPERIENCE NEEDED — PHYSICAL

3. NATURE AND CONDITIONS OF WORK

LOCATION	POSTURE	SPEED	ACCURACY	SIZE OF MATERIAL	AUTOMATICITY	HEALTH HAZARDS	DANGEROUS FEATURES	ACCIDENT HAZARD

MACHINES USED — PERSONAL TOOLS REQUIRED

TOOLS USED — TIME REQUIRED TO LEARN OPERATION

DEPARTMENT HEAD — EMP. DEPARTMENT — DATE

FIG. 41.1. Simplified form of job specification.

   1.3. Recommendations of friends and relatives by satisfied employees.
   1.4. Former employees who were in good standing when they left.
2. Outside sources.
   2.1. Direct application in person or by mail.
   2.2. Employment agencies.
      2.21. Union agencies.
      2.22. Government-sponsored agencies.
      2.23. Private agencies.
      2.24. Religious and fraternal agencies.
      2.25. Employers' groups.
   2.3. Other business exchanges.
      2.31. Reciprocal agreements with certain employers to supply men.
      2.32. Agreements as to layoff and discharge.

[2] *Ibid.,* Chapter 6.

- 2.4. Contacts in other localities.
  - 2.41. Labor-department reports.
  - 2.42. Newspaper advertisements.
  - 2.43. Trade associations.
  - 2.44. Governmental employment offices.
- 2.5. Educational institutions.
  - 2.51. Public schools.
  - 2.52. Trade schools, both public and private.
  - 2.53. Colleges.
  - 2.54. Training schools of manufacturers of special equipment.
- 2.6. Advertising.
  - 2.61. Newspapers and trade journals.
  - 2.62. Radio, posters, billboards, etc.

Space will not permit a detailed discussion of all these sources, but a few of them merit special consideration. Advertising as a rule is of questionable value save for persons of special skills or training. It is usually resorted to only when there is a labor shortage and results in taking workers from another employer, who reciprocates in kind, with little if any social or economic advantage.

A large proportion of new workers must necessarily be selected from those who apply at the office, although this source of supply is generally the least satisfactory, particularly in good times. Applications by mail are frequently received, and they form a satisfactory source, particularly for firms with good employment reputations, who are likely to attract workers already employed. Of course, follow-up interviews are necessary before selection, regardless of the amount of correspondence. Workers already employed by the company are likely to recommend others for consideration. These recommendations may easily prove one of the best sources of supply, since workers know plant conditions and are not likely to make recommendations unless they believe that these others will also be satisfied. In times of job scarcity, however, this practice may become a problem, since friends of the workers who are not worthy may exert pressure for recommendations for employment. It is an excellent idea to give the worker a card for his friend which serves only as an introduction, with the understanding that he will have to meet the company requirements to be employed. Care should be taken also not to place too many foreign-speaking men of the same nationality or too many persons of one religious faith in a single department, or cliques will develop.

Of all the contacts which can be developed between the employment department and outside organizations, those with employment agencies need the most careful study. Some employment agencies go about their work in a professional manner and will recommend only persons who they feel confident will fill the opening. In every large community, how-

ever, there are many agencies which come just within the letter of the state law governing their operation and which are not good contacts for the employment department. Public employment agencies are now found in nearly all communities. In some localities these public employment offices are efficient, and in other areas they leave much to be desired.

In some instances trade organizations are valuable aids. In some industries where collective bargaining has been established, particularly in the clothing industry, joint offices have been provided as an aid to the plant-employment managers. Schools, colleges, and specialty concerns who train workers in business practice, such as filing-device distributors, all form valuable contacts. Frequently close relationships can be built up with technical high schools that will yield a very satisfactory source of supply in their graduates. Candidates for future executive positions are found more and more among graduates of colleges, and many such institutions have provided departments which aid the employment manager to get in touch with their students, as well as with graduates who have been in the industrial world for some years.

The employment interview.[8] In the interview with an applicant the employment department has one of the best opportunities to justify its existence. It is not only in the selection of successful candidates that this is true, but also in the method of selection, in the method of rejection, which should not create any ill will toward the firm, and in learning from the candidate those points which are pertinent to a consideration of whether he is likely to be a permanent member of the working force. There can be no cut-and-dried method of interviewing. Each person must be treated in a different manner and in a way which seems best to fit his individual case. The successful interviewer is one who can put the applicant at ease and get him to talk freely about his experience and desires.

In all employment work the major task of the management is to make the employee or prospective employee act in a wholly natural manner and "open up" in conversation. For this reason, it is desirable that all features of the employment office be constructed with this idea primarily in mind. It is therefore desirable that, when the majority of persons being employed are women, the interviewer should be a woman, and when the majority of applicants are men, the interviewer should be a man, inasmuch as workers seem to express themselves more freely to members of their own sex. This general rule holds true also for the higher positions

[8] See Guy Wadsworth, Jr., "How to Pick the Men You Want," *Personnel Journal*, Vol. 15, March, 1936, p. 335, for a more detailed discussion of this subject. Also see Scott *et al.*, *op. cit.*, Chapter VII, "The Interview as a Tool of Personnel Management."

in the personnel organization. Courtesy on the part of members of the employment staff is a fundamental necessity, if the plant is to be regarded in the community as a good place to work.

The setting for the interview should be in keeping with the over-all plant environment. It should be clean and comfortable but avoid ostentation and display. An employment office of a bank or a department store may well be more elaborately furnished than that of an industrial plant.

It is the task of the interviewer to sell the plant to the applicant and to sell it to him fully, but it is likewise his task not to oversell either the plant or the job. The basis of many other personnel activities is to be found in the impressions gained by the worker in his first few days on the job. If the interviewer is successful in his relations with the workers whom he interviews, he can develop an attitude toward the plant which will go far toward making the worker feel at home during the first trying days. No matter how badly a worker is needed, it is distinctly bad policy to oversell the job by exaggerating its good points or by consciously or unconsciously not mentioning all its bad points. The bad points will be discovered quickly by the worker. If he is not prepared for them, there is the likelihood that they will appear even worse to him than they actually are.

The application blank. Application blanks have frequently been regarded as the most important feature of the process of selection, and many of them have been designed with the aim of asking the applicant every possible question that could be devised. This is wrong. Application blanks should be made as simple as possible; the questions asked should all have a bearing on the applicant's fitness for a particular job or right to membership in the organization. Personal questions, which may aid the interviewer in determining the desirability of the applicant should, however, be asked in the interview rather than on the blank. Furthermore, the application blank should be handed to the applicant in a way that will secure his cooperation in filling it out, rather than have the effect of making him look at it as a piece of useless mechanism which must be filled in before the real business of the day can start.[4] If the interviewer is really to learn pertinent facts, the applicant must be made

[4] Some employers have the applicant fill out only an abbreviated preliminary application blank until he has been interviewed by the employment office. This practice saves much time and prevents annoyance to many applicants. If the employee is to be hired, either he or an employment representative fills out a detailed application blank, which is made a matter of permanent record. If the applicant is not employed immediately but appears to be a desirable man for future call, he may be requested to fill out the more complete card.

to feel at home. He is not likely to feel at ease in walking into a new plant, unless he is the undesirable type of applicant known as the "floater." The application blank may readily be used by the interviewer as a means of beginning the conversation with the applicant in an attempt to find out what kind of person he really is. Such applications form a valuable file of eligible workers for whom there are no immediate openings. When the application blank is used as a file for future prospects, it is necessary to recheck this file at stated intervals to keep it alive. One method is to send out postal cards at the end of a given period asking the applicant to notify the employer if he still wishes to be considered for a position. If there is no reply or a negative reply, the application blank is destroyed.

Employment tests.[5] Much has been written and many experiments have been made with employment tests, both trade and mental, including general intelligence tests and rating scales. Their place in industry is still a matter of controversy, but it may definitely be said that they cannot be relied upon too extensively, unless they have been designed and checked especially for a particular job. *Tests are frequently of more value in determining a minimum below which the applicant has little or no chance for reasonable success than in rating the relative merits of applicants whose scores are high.* Trade tests, which presume to test directly the abilities of the applicant for the job by having him do some work of the kind in which he is supposed to be skilled, unquestionably eliminate the bluffer. But frequently it is necessary that a worker be given a chance to produce over a long period, because of the peculiar type of work or arrangement of machinery in the plant, or because of the scarcity of skilled workers at the time. The foregoing statement regarding minimum scores is also applicable to performance tests. A large food distributor devised a simple test taken from actual computations required of route salesmen. It was found that those who made four or more errors within the allotted time were almost certain to have difficulty with record keeping and making change. On the other hand, a perfect score did not insure a successful route salesman or well-kept records. The test eliminated the ones who could not perform, but it did not insure that the others would perform. Performance tests are valuable for simple kinds of work, such as typing.

Trade tests, which consist of showing the applicant a picture of a machine and then asking him a series of questions concerning it, or asking him for other similar trade information, are somewhat more valuable,

[5] See Scott *et al., op. cit.,* Chapters XIII to XVII; see also Joseph Tiffin, *Industrial Psychology,* Prentice-Hall, 1942.

provided that the test is used as a part of the general interview, and not given like a civil service examination. Although the poorest worker may readily pass the best examination if his mind happens to run in such channels, nevertheless, if properly devised, such tests may gauge the actual ability of the applicant with considerable exactness.

Mental tests, such as general intelligence tests, are of less proved value in the selection of workers, except for setting minimum standards, thus eliminating certain applicants. Even in this connection care must be exercised. An individual who could not learn certain skills under competitive conditions within the required time limits imposed by industry may have acquired these skills under less exacting conditions and be an average worker. He may fail the general intelligence test and yet pass the performance test. Intelligence tests may give some idea of mental quickness or general knowledge, but they have not been developed to constitute a convincing test of fitness for specific jobs. Mental tests which are designed to check a particular ability may be regarded as somewhat more successful. Thus a test which indicates quickness of perception may be utilized as a partial guide in hiring persons to do assembly work on small parts. Rating scales, which may be of some value in the promotion of executives, provided the rating is intelligently done, must be used with great care in the selection of applicants for any position. All methods of character analysis by means of physiognomy have been proved useless, and most advocates of these methods found to be complete charlatans. Any test based on such ideas is in reality only making the applicant for employment subject to the fundamental or acquired prejudices of the interviewer.

The foregoing statements regarding employment tests should not be interpreted to mean that they should be thrown out entirely. As a matter of fact, they ought to be employed much more generally than is now the practice, but they should be used with discretion and as aids, not final determinants in themselves.

Physical examinations. In plants having physical examinations of applicants, with a doctor always in attendance, this examination may readily be given before the worker is finally employed. It is wasteful to spend the time necessary to fill in all employment records unless the applicant can meet the physical requirements for the job. In plants to which the doctor pays only periodic visits, the examination may come after the worker has been provisionally on the job for a day or two. Practice depends mainly on the purpose of the examination. It is largely used today, not as a means of complete rejection, except for communicable diseases, heart or respiratory disorders, and a few physical handicaps, but as an aid to intelligent placement and follow-up. Unless there

are physical examinations, it is very likely that workers will be assigned to jobs which are beyond their strength or to which they are peculiarly unadapted from the physical standpoint, when they might as well have been assigned to tasks which they could satisfactorily perform. Many workers and some employees' organizations have objected to physical examinations because they have believed them to be predicated on the idea of rejecting the employee if he were not one hundred per cent perfect physically. Of course, there is usually no such idea; nevertheless a certain fundamental reaction springs up in large numbers of men against taking a physical examination before they are given a job. This fact must be recognized and guarded against. This attitude on the part of workers is much less prevalent today than formerly. Many organizations have been using complete physical examinations for twenty-five years or more and seldom encounter any complaint. On the other hand, there are some communities where physical examinations for jobs are relatively unknown.

Introducing the worker to the job.[6] The function of employment does not end with acceptance of the worker by the employment department and with his acceptance of the job. One of the best ways to make a new worker dissatisfied with plant conditions is to have him misunderstand them. If he is started at work without any adequate explanation of the aims and policies of the concern, and if his job is detailed and repetitive, day in and day out, is it surprising that he will not readily listen to accounts of the "real aims of the plant"? It is desirable that he be given a bird's-eye view of the history, policies, and aims of the plant and be shown his connection with them all. One of the most common ways of attempting this orientation is by means of a booklet which is handed to the employee at the time he begins work, and which may have any title except "Regulations."[7] Some concerns place the name of the employee on the cover of the book. As previously stated, a personal introduction of the worker to the man under whom he is going to work is a necessity. Either the foreman or the employment-department representative should be careful to introduce the new employee to those around him and to show him the facilities for his personal comfort, such as locker rooms and washrooms, as well as those aspects of plant routine which intimately concern him, such as entrances, clocks, methods of securing pay, and various service features.

Not only should the worker be properly introduced to his job; he should also be carefully followed up, especially during the period immedi-

[6] See Scott *et al.*, *op. cit.*, Chapter XXI, "Introducing the Worker to His Job."

[7] See "Interpreting company policies to employees," in Chapter 40.

ately after his employment. That is the time of most difficult adjustment, during which the heaviest turnover figures are run up. In some plants, representatives of the employment department, sometimes even the interviewers themselves, go to the various departments and talk with those who have been recently hired. In such talks an attempt is made not only to secure the reactions of the worker to his job but also to check up on the judgment of the employment department, so that transfers may be made, if necessary and advisable, at the time when they will do the most real good.

The sponsor system is used by some employers. Certain reliable employees in each department who have demonstrated their interest in their fellow workers are designated to aid the new employee in getting adjusted to his new environment. The sponsor accompanies the new worker to the lunchroom, shows him the locker room, explains the many rules and customs that have grown up in the department, and in general conveys to the newcomer the idea that there is at least one member of the group on whom he may call for guidance and upon whom he may look as a friend. The sponsor may be paid a nominal sum for this service, or he may be granted certain special privileges, such as additional days of vacation with pay, permission to leave and enter the plant without punching a card, or special parking privileges. The assistant foreman or group chief may assume the responsibilities of the sponsor, especially in relation to most of the auxiliary services.

Transfers and promotions.[8] Inasmuch as the employment department is charged with providing a satisfactory working personnel for the organization, it follows that control of transfers from department to department or of promotions must rest largely with it.

A promotion system, which frequently involves transfers, is a most valuable adjunct to any personnel policy if it can be worked out. Lines of promotion should be clearly defined wherever possible, and every effort made to create a real promotion policy. Frequently simple promotion schemes are effective, such as transferring a worker from dirty or greasy work to clean work, or from a night shift to a day shift. One reason why a well-developed system of promotions and transfers is necessary is that, if some such scheme is not worked out, there will be a tendency for the department head to keep his best workers in the jobs that they hold. He may seek immediate low cost rather than ultimate low cost. If morale is important to ultimate low cost, as it unquestionably is, promotions are necessary, for nothing builds up morale more readily than does a real promotion plan. This does not mean that personnel should

[8] See Scott *et al.*, *op. cit.*, Chapter XII, "Transfer, Promotion, and Discharge."

never be brought in from the outside for executive or subexecutive positions. On the contrary, if an organization fills all executive vacancies from the ranks, it may lack the drive that comes from new ideas, and any promotion policy must be tempered with this knowledge. To promote solely from within lays an especially heavy burden upon initial hiring. If men capable of rising in the organization are not hired at the lower levels, they will not be available for promotion when a vacancy arises.

Another factor in promoting from within is the tendency to adjust the working force to absorb at the lower levels the work of the promoted employee. It is a well-recognized fact that somewhat more than the required number of men is usually carried in large departments, particularly on the lower levels among day workers or even group workers. In such situations the promoted employee is seldom replaced. The same production is usually turned out with the reduced number of men, resulting in an increased efficiency per man.

A promotion scheme, including a line-of-promotion chart, cannot always be drawn up and posted, particularly in small organizations. Nevertheless the employment department can be always working toward such a scheme; and in large organizations, where there are the most blind-alley jobs, the development of the idea is easiest. The aim is to make sure that the worker has the maximum responsibility and earnings, and the firm has the benefit of his greatest ability. In working out such a program, quantity and quality of work, length of service, attendance record, age, and physical and mental fitness must all be taken into account.

Records of discharges, quits, and layoffs. Policies differ concerning the extent of control of the personnel division over the discharge of employees. In most plants which have developed employment departments, the employee must at least leave the plant through the employment office, in order that a record may be obtained of the reason for severing the connection.

In many organizations the policy is that the department head may discharge an employee only from his department. In principle this program is sound; and, when it is carried out in good faith by all parties concerned, few if any serious disciplinary situations arise. The personnel representative, usually the chief employment officer, handling such cases must use real human-engineering principles to get maximum results. The foreman is jealous of his reputation; so is the workman. Both parties are anxious for a chance to "save face." Each man desires not to lose status in the eyes of his associates. When possible, it is best to transfer the worker to a division of the plant as far removed from his original job

as is practical. Each party usually feels better about the matter when the employment officer can tell the worker that his former foreman recognizes that he may make good in another department and has recommended that he be given a transfer if possible. A skillful employment adjuster frequently secures the cooperation of the foremen to the extent that he will call the employment office before discharging the worker.

In the event of a discharge special care should be exercised to make the cause a matter of record. This may well be signed by the foreman, the superintendent, and the employment officer with any other witnesses who are available. Such a record may be invaluable later in a hearing before the National Labor Relations Board if the company is charged with discrimination because of union activities. In some states unemployment compensation does not become payable so quickly when an employee is discharged from one department and refuses to accept a transfer to another. Unemployment compensation now makes it highly desirable to have accurate records of employees' quitting of their own accord.

Many times men are laid off from the working force of a department because of a reduction in its work but can readily be used in other departments of the concern. In such cases an orderly procedure, rather than a mere dismissal of the employee, will frequently result in the retention of many persons who can be used in other positions.

Labor turnover. A statistical analysis of the number of workers employed in each department, the number hired over a period, and the number of "exits," carefully classified, is a measuring stick of the effectiveness of an enlightened labor policy and of the operation of the employment department. The exits should be carefully subdivided as to voluntary withdrawals, layoffs, and discharges. It is in the subdivisions of these main causes of exits that the most valuable data will be secured for the development of the personnel policy. Whether the voluntary withdrawal is due to dislike for the work, a "better job" (which frequently should be interpreted "higher pay"), conditions at home, or other reasons should be fully investigated before the employee is allowed to leave. Sometimes the real reason cannot be ascertained; but at other times, if as much care is given to the interview when quitting as is given to the interview at selection, some real information will be secured for policy determination. The first cause given by the worker cannot always be accepted as the real one. In addition to a compilation of causes of turnover, the employment department can prepare other interesting and valuable statistical information, such as an analysis of the working force according to earnings, length of service, or any other basis desired. These

analyses can also be combined with turnover statistics by departments as an aid in policy formulation and better selection.

The term *labor turnover* has acquired special statistical significance. It has had different interpretations at different times and by different groups. The *net labor turnover,* the most commonly used term at present, may be defined as the number of replacements per one hundred workers in the average working force. There are several other definitions, but the one given is in quite general use. The formula for computation is

$$\text{Net labor turnover} = \frac{\text{Total replacements}}{\text{Average working force}} \times 100$$

or

$$T = \frac{100R}{W}$$

The Bureau of Labor Statistics of the Department of Labor collects these data and publishes a monthly index for the entire United States broken down into major manufacturing industries. The figure may be expressed on a monthly or on an annual basis. Unless otherwise specified, the annual rate is used. Although this index is by far the most reliable one available on a large scale, it is subject to certain limitations. It is a crude unadjusted index and does not take seasonality into account. Again, it does not distinguish among the causes for labor turnover. Replacements of all types, regardless of cause, are lumped together. The cause of replacements is of major significance for remedial personnel control. This fact has led many employers to keep a special refined turnover rate for their own guidance. In this case their refined net turnover rate is the ratio of the avoidable separations to the average working force (per hundred). This formula is $T = (S - A)100/W$, where A stands for unavoidable separations, S for total separations, and W for the average working force for the period.

CHAPTER 42

EMPLOYEE SERVICE ACTIVITIES

The nature of service activities. *Service work includes all those activities which are not directly concerned with the worker in his relation to production but which make the plant personnel a healthier, sounder-thinking, more forward-looking group.* To avoid the pitfalls that caused the idea of *welfare work* to fall into disrepute, the plant must studiously avoid any semblance of the attitude, "See what we are doing for you." The only excuse for a management's including service work in its industrial program is that it will make the employees a group of citizens better able to carry on the productive processes, or that it constitutes a development which has been approved by the express will of the employees. A safe principle for guiding the inauguration of service activities is to have them grow out of the work situation and be in most instances the result of employee cooperation. In all instances a more favorable attitude will result if the employees participate in the determination of the general nature of the activities.

First aid and medical service. Many organizations in which there are no physical examinations for employment have a plant doctor, either on a full-time or a part-time basis. The proportion of time that he is at the plant usually depends somewhat on its size. The doctor generally maintains a dispensary with a nurse in attendance, not only for accidents, but for rendering aid and counsel in health matters (see Fig. 42.1). If the plant is fairly large and the doctor on a part-time basis, the dispensary is usually in charge of the nurse, who, when occasion demands, also goes out to the homes of workers who are ill and who desire her aid. This home visiting may take the form of a systematic follow-up of all workers who do not report for duty on a given day. When thus organized, the program has the added purpose of decreasing absenteeism. Such home visiting must be carefully handled if the attitude of paternalism is to be avoided.

The greatest function of the medical department, if organized to give health service, is to keep the worker well and on the job. If the confidence of the workers can be secured so that they will report to the dispensary when they first feel ill, a large share of absenteeism will usually

be eliminated, and the spread of an epidemic within the plant may possibly be checked.

Communicable diseases demand practically daily watchfulness, with foremen instructed to be observant. Likewise, health officials must be quickly informed of epidemic or multiple illness of all types. Provision should be made for treatment of trivial illnesses, first-aid, dental prophylaxis, and ocular attention of a preventive and emergency nature, as well

Courtesy, General Motors Truck and Coach Division

FIG. 42.1. First aid. There is a series of private rooms in which all major cases are handled. This dispensary is completely equipped with X-rays and various therapeutic devices.

as the usual surgical treatment of minor injuries. Except in isolated communities, as a rule, major surgery and sickness should go to outside hospitals or elsewhere. Finally, compensation approvals must pass under the physician's scrutiny.

Industrial physicians should be allowed to lay stress on health complaints made by workers and not wait for sickness disability. Surgery, in the face of disability statistics, certainly requires much less stress than ordinary sickness. Real occupational diseases constitute a very small part of the sickness disability occurring among workers. It has been found that sickness causes twenty times as many cases of absenteeism as accidents and is responsible for seven times as much loss of time from

work. True, the greater portion of sickness disability among workers is extra-industrial in nature and is equally prevalent among adults of like ages and sexes in the general community, perhaps more so; but a considerable part can be greatly influenced by industrial environment and methods of personnel supervision and, as such, is capable of considerable reduction in the matter of days of absence from work.[1]

A medical department can do much to reduce compensation claims and loss of production time, but only if it is skillfully directed. Industrial physicians and nurses must understand the human side of their daily contacts. They must at least be given a cheerful place in which to work, and one that is central enough to make it convenient to all the workers. It has been found impracticable for most plants employing fewer than 500 workers to employ a physician on full time. Plants employing from 500 to 2000 workers may or may not employ a full-time physician; plants with more than 2000 workers almost uniformly do. These facts, together with the cost of medical-department operation, have been worked out in a very complete study by the National Industrial Conference Board.[2] This study indicates that the annual cost per worker of well-organized medical departments averages about $4.50, the cost for the smaller plants being higher, or in the neighborhood of $6.00. Five large companies in the Chicago area reported that their costs for first aid and medical service for 1945 averaged from $5.00 to $16.00 per capita. Naturally this wide variation in expenditure represents a marked difference in the activities of the various medical departments. These figures cannot be viewed properly without considering the reduction in compensation claims and lost time and the increase in general contentment, due to the good health that such departments bring.

The well-organized medical department is able to collect a mass of highly useful data for the personnel and production executives concerning unhealthful conditions and unsafe operations within the factory. The checking of causes of absence may be done by a factory nurse. The only possible excuse for entering a workman's home when he does not report for work is to render assistance if he is sick. If it is found upon calling that the worker's absence is due to any other cause, there is but one procedure, namely, to withdraw promptly. Any other action is paternalistic to an impossible degree. Nevertheless, a clever factory nurse can secure much useful information in making her rounds, and her value in reducing absences is not confined to aiding ill workers to return

[1] Adapted from address by Emery R. Hayhurst, M.D., Ohio State University and State Department of Health, Columbus, before Conference on Women in Industry, Special Bulletin No. 10, Pennsylvania Department of Labor and Industry.

[2] National Industrial Conference Board, *Research Report No. 37*, pp. 10–11.

to work more promptly. Her visits have a moral value, too, inasmuch as they indicate more strongly than any amount of regulation by the management, the importance of being on the job. No plant can long afford to carry workers who are consistently absent without good reason, and the factory nurse is the proper person to find out the cause. The visiting nurse and doctor serve as the basis for administration of sick funds maintained by any mutual-benefit association in the plant. The nurse should also be closely in touch with any charitable organizations in the community which might be interested in aiding workers whose illness has left them temporarily in bad financial situations. Some companies feel strongly that it is very desirable that the handling of such cases be called to the attention of such duly organized agencies and left with them.

Recreational activities. Recreational features may take the form of dancing, music, or speeches during the noon hour; plays, band concerts, or dances given by workers at intervals throughout the year; or the development of clubs and clubhouses. These features, particularly the last, are bound to fail unless the basic wage of the plant is right. The workers will quickly see that such activities are costing the firm a considerable outlay and will be likely to demand that the money be put into their pay envelopes, unless they are already fairly well satisfied with their wages. If professional talent is available, it may be called upon infrequently for short concerts during the noon hour with satisfactory results. Plays and dances are valuable if they are fostered by the employees through organizations of their own, which call upon the service department only for guidance. Such activities are particularly workable in small towns; however, the employees of Western Electric Company, Hawthorne Station, Chicago, have had remarkable success with them. Clubs, particularly country clubs, laid out on a large scale, cannot possibly be successful unless the management has the complete good will of its employees. There is too much opportunity for the criticism of large expenditures. If the esprit de corps has not been worked up to a high pitch before the opening of the club, it will be difficult to get the whole-hearted cooperation of all elements within the working force for its support. To avoid the charge of paternalism, clubs, after formation, should be operated as employees' organizations; and, since they involve large investments on the part of the company, it is necessary that steps be taken when they are organized to prevent internal politics in these organizations from wrecking the project. If a plant is properly situated, and if all fundamental conditions are right, there is no feature of service work that will do more to secure the mutual understanding of all elements within the plant than will a club. If this is to be true, however, it is essential that

all employees, whatever their plant status, be given an equal status within the walls of the club.

Athletics, while valuable, have been carried to an extreme in many organizations. Interdepartmental competitions tend to raise the spirit of the departments, and girls' or men's basketball teams and men's baseball teams are particularly successful. Athletics develop health and encourage that most valuable asset to any industrial concern, teamplay. They develop plant consciousness and leaders. If plant teams are formed, the tendency toward professionalism and the hiring of workers merely for their athletic ability must be guarded against. Even teams composed of bona-fide employees tend to make the winning of games their primary interest during the playing season. At times this definitely interferes with the productivity of the individual workers involved. In small towns, where the company team is in reality the town team, these objections are frequently wholly out-weighed by the good will which the team builds up in the community. But too much time, too much attention, and too much money can readily be bestowed on athletic work that emphasizes competitive rather than health features.

Restrooms for women have social as well as health values.

Restaurants, cafeterias, and lunchwagons. The maintenance of plant restaurants and cafeterias has become almost universal. Even when the neighborhood is blessed with fairly good places to eat, it has come to be regarded as desirable to institute a plant cafeteria. Such a cafeteria not only makes possible the development of esprit de corps through the meeting of fellow-workers but also insures that employees will be properly nourished for the afternoon's work. These features make the restaurant a dividend-paying investment. Since profit is ignored, costs in factory restaurants are usually less than those in commercial restaurants. Costs are usually based on the price of food and service, overhead being eliminated. For the poorer portions of the working force and for women workers who are also housewives, the factory restaurant provides an opportunity to get at least one good meal a day.

The establishment of a plant restaurant makes possible the enforcement of regulations against eating in the workrooms. In some industries, such as clothing factories, food-preparation industries, and drug and chemical industries, it is necessary to prohibit eating in the regular workrooms.

In most industries it is desirable to have a clean lunchroom of some type. The cafeteria style of restaurant finds most favor because of the lower cost and the speed of its operation (see Fig. 42.2).

When it seems desirable, a restaurant company or an individual may run the plant restaurant on contract, provided careful supervision is

maintained over its operation. Wherever possible, it is desirable that the restaurant be operated by the plant itself.

The actual management of the restaurant provides an excellent opportunity for promoting industrial democracy. It has been found successful in some instances to have the restaurant operated by an employees' club or other employees' organizations. In one large midwest organization

Courtesy, the Cleveland Graphite Bronze Company

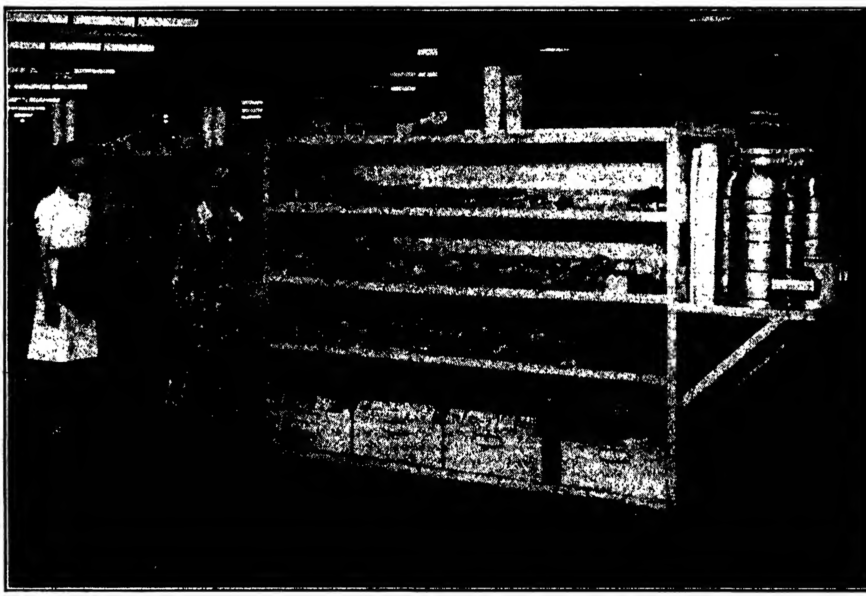
FIG. 42.2. An unusually attractive employees' cafeteria.

the restaurant and employees' club are operated by the purchasing department but are under the supervision of a committee representing the employees.

The restaurant may readily be made the center of the service activities of the firm. If entertainment features are desired, they can be provided in the restaurant, either during the noon hour or at other times. The restaurant can be made the center of employee or departmental functions and provides an assembly room upon which there is little desire or likelihood of encroaching.

In many companies a lunchwagon makes the rounds in the middle of the morning and afternoon (see Fig. 42.3). These lunchwagons serve

sandwiches, soup, coffee, soft drinks, candy bars, and similar items. The workers usually take an informal rest period at this time and buy items from the wagon or eat from their lunchboxes. The time out for these brief lunches does not retard production as much as some people think. In many instances production is even greater than it would be with no time off.



Courtesy, the Cleveland Graphite Bronze Company

FIG. 42.3. Lunchwagon ready to start its journey.

Restrooms and locker rooms. There are certain features, generally classified under service work, the desirability of which cannot be questioned, from the standpoint of either the employer or the employee. They are in reality a portion of any sound policy of operation and may be placed under the personnel division merely for convenience of administration. Such activities are the operation of adequate locker rooms and washrooms. In many organizations these rooms are under the direct supervision of the department head and are kept clean by the janitor force just as is the rest of the department. Regardless of the organizational setup, the personnel department will be interested in the adequacy of these facilities, just as it is in plant safety and sanitation. Locker rooms should provide individual lockers, and wash rooms should be constantly supervised and kept clean. Restrooms for women (Fig. 42.4)

come under this heading and are uniformly desirable, if not maintained on too elaborate a scale.

Employee financial activities. Funds which are built up through voluntary associations of employees are valuable from the standpoint of the employee and the plant. Such funds are those of the building and loan

Courtesy, Western Electric Company

Fig. 42.4. Women's restroom.

associations and benefit associations, and savings funds. Company group-insurance plans and retirement plans are also very successful. Many companies have not been especially successful in operating employees' savings funds themselves, but these same companies may well urge the establishment of Christmas savings clubs, vacation funds, or building associations and can lend the time and experience of one or more of their executives or lawyers to act as an adviser to such groups. The board of directors of such associations, to be successful, must be composed almost entirely of workers, with probably one representative of the management, who will sit for the purposes named. Associations

of employees created for savings purposes of one kind and another form an excellent foundation for the beginnings of cooperative management. Savings funds usually work out best if they have some particular purpose in view, such as Christmas savings clubs.

Credit unions or workers' banks have been signally successful as a medium for saving for workers who have a surplus and as a source of funds at reasonable rates for workers in need of immediate funds. They may be organized under either state or national laws. The workers themselves *control* them. Management may underwrite them to the extent of providing free office space and clerical aid in some instances, such as making payroll deductions for repayments or doing bookkeeping.[3] The credit union of one Chicago firm has deposits exceeding $1,000,000. Dividends are usually limited to 6 per cent, with excess earnings going to surplus. During recent years the dividends have seldom been more than 3 per cent because of a falling off in the demand for loans from employees and the low interest rates on the available investments, which have been primarily government bonds.

Group insurance. Group-insurance plans were formerly utilized largely by companies as a means of putting a premium on length of service. They were sometimes used together with increased wages for length of service, but frequently formed the only length-of-service bonus. The provision for group insurance has increased greatly in recent years. Length of service is still a vital factor in some group-insurance programs. Nearly all of them require a waiting period, such as 3 or 6 months, before the worker is eligible. Many of the programs today are based not on the length of service but on the earnings of the employees; for instance, employees earning $4000 and above may be eligible for $5000 insurance; those earning $3000, $2000, $1500, and $1000 or above may respectively be eligible for $4000, $2500, $2000, and $1500 in group insurance. Where length of service is the determining factor, it is not unusual for the company to bear all the expense, and the insured amount is usually lower. This practice, however, is by no means universal. The advantages to the employees are lower rates and no physical examination because the policies are taken out on the group basis. One disadvantage of group insurance where the worker pays most or all of the cost, from the standpoint of the younger worker, is the fact that his rate is often higher than it would be if he bought the same protection alone. This fact has encouraged company contributions, which is the prevailing system.

[3] See R. F. Bergengren, *The Credit Union: a Cooperative Banking Bank,* Credit Union National Extension Bureau, Boston, 1931; also annual reports of the Farm Credit Administration, a bureau which administers the Federal Credit Union Section.

Retirement plans. Retirement plans are usually worked out on a scale which varies with length of service. One plan provides for the retirement of all employees of 65 years (women, 55 years) after 20 years of service, or the retirement of employees of 60 years (women, 50 years) after 30 years of service, with certain special provisions for others. The retirement payments are 30 per cent of the average pay per month of service during the 10 years immediately preceding retirement, with a minimum of $20 per month. The plan is in charge of a Service Retirement Board consisting of five officials of the company, who have discretionary power to retire others than those affected by the major provisions of the plan, for instance, employees who become physically incapacitated for service.

Some retirement plans are regular annuities purchased from insurance companies. Sometimes the worker contributes a specific amount, such as 3 per cent, to the plan, and the company matches his contribution. In some instances company contributions to retirement plans have been reduced by the amount paid by the company to the Social Security Fund for old-age pensions.

Company stores. Companies that manufacture wearing apparel or other articles which employees are interested in purchasing usually maintain retail counters or stores at which employees may purchase the product at wholesale prices. Other companies operate retail stores for the purpose of selling groceries and other necessities. These stores are best run on a cooperative basis, if criticism and ultimate failure are to be avoided. Occasionally these stores sell coal and other expensive necessities on the weekly basis. Articles are usually priced on a basis of cost plus handling charge, with inventories taken frequently and prices adjusted accordingly. Sometimes there will be an attempt to make a profit, with this profit turned over to the mutual-benefit association of the plant. Some company stores remain open all day, when either workers or their families are permitted to make purchases. Other stores are open only just before and after working hours and at the noon period. A large store may utilize a box into which orders can be dropped. These orders are filled during the day and are ready for the worker when he calls for them in the evening.

Company stores were more prevalent just after World War I, when retail prices were soaring. Opposition from local merchants is very common, especially when the store does not limit its activities to the company's own products but does a general business. A few years ago the Ford Motor Company operated a gigantic store for its employees in the Highland Park plant. Local merchants complained bitterly, and eventually the store was closed.

CHAPTER 43

TRAINING IN INDUSTRY

Divisions of training. There are two major divisions into which the industrial educational and training programs may logically fall, namely, (1) specific training for job or occupational tasks, and (2) a general educational program which has as its objectives raising the general intellectual level of the group, transmitting company policies to employees, training in health and safety practices, promoting good citizenship, and developing morale. Under either of these two broad divisions executive and supervisory training, factory-worker training, office-worker training, and sales training are provided. Practically all business enterprises engage in both these types of activities in a limited way even though no formal programs exist. Only the larger organizations can spend the money necessary to have an organized effort in all these fields.

Much of the strictly educational work can frequently best be carried on by the formation of clubs among the employees, which will be able to conduct the educational work with but little guidance from the personnel department. If a plant library, which is sometimes particularly desirable in small towns, is to be established, it can best be put under the supervision of some employees' club or association, although it should not be necessary that any employee to be a member of the organization in order to secure the benefits of the library. Education in thrift and the giving of sound financial advice are frequently possible but can probably best be carried on through the plant paper. If there are savings funds or other similar plant organizations, they can best handle thrift education.

A few of the larger corporations, such as the Goodyear Tire and Rubber Company, the Ford Motor Company, the Chrysler Corporation, and the General Motors Corporation, have at times conducted elaborate educational programs. The Chrysler Corporation has the Chrysler Institute of Technology; the Ford Motor Company, the Edison Institute of Technology; and General Motors, the General Motors Institute of Technology at Flint, Michigan. It is true that these schools have as one of their objectives the training of executives and therefore may reasonably be classed under the specific heading of training for executives. On the

other hand, many courses are offered in the school at Flint which are of a general educational nature. It is doubtful whether such programs will increase in number, especially in the light of changing educational trends in the regularly organized colleges, such as the cooperative courses at the University of Cincinnati, Antioch College, Massachusetts Institute of Technology, and the Technological Institute of Northwestern University. The evening classes for strictly educational purposes have grown rapidly in recent years.

The house organ as a medium for training. One of the most successful ways of disseminating personnel policies is through the plant publication. Such an organ will thoroughly acquaint the employees with each other and with the management, and it may be readily utilized as a means of expressing the fundamental concepts of the employer and the management and, frequently, the viewpoints of the workers as well. The plant paper is particularly valuable in this connection in organizations whose units are widely scattered, although its value is by no means limited to such cases. Of course, many plant papers are published which make no attempt to cover labor policy and are put out merely with the hope of increasing the good will of the employees in some general way. Although these papers are usually valuable, it is to be regretted that they do not make themselves additionally useful by considering labor policy. Not much space is needed for this purpose, and most of the magazine may still be used for educational, inspirational, and local-interest material. The first requisite of an employees' paper is that it be interesting, or it will serve no purpose. Most of the paper must describe employees' activities and relate interesting facts about the individual departments or the plant as a whole.

Methods of instruction. The methods of instruction in industry are as varied as they are in organized schools. The different methods may in general be classified as follows: lecture, quiz, laboratory, project, conference, correspondence, and various combinations of these. The lecture method is effective for imparting facts, such as informing a group of new employees regarding the policies of the company. Slides and moving pictures may be used in connection with the lecture method, as well as with other methods. The laboratory method is particularly valuable in imparting certain skills and other information concerning machines and materials. Correspondence courses may be used where the employees are scattered and special information is to be taught. The correspondence method is the least desirable of all, but is the only one practicable under some circumstances. The conference method is particularly suited to the instruction of adults and has been popularized in executive training for the past twenty years.

> The Purpose of the foreman conference is to stimulate individual thought, develop initiative and the powers of attacking new problems on the part of the foremen by means of informal discussions in groups of about twelve men. The foreman-conference method differs radically from the conventional teaching methods ordinarily employed. A chairman, or conference leader, presides over each group, but he is not a teacher; his duty is simply to use questions in order to develop free discussion among the members of the group and keep the discussion from deviating from the desired goal. By the conference method, foremen teach themselves.
>
> The conference method of foreman training is of particular value on account of its flexibility. The text material plays only a minor role, practical experience forming the background for every discussion.[1]

At a conference sponsored by the General Motors Institute of Technology, Mr. Frank Cushman of the Federal Board for Vocational Education, Washington, D. C., was the conference leader on the general subject of methods of instructing foremen. Out of this conference, attended by personnel directors and other key executives, the summary presented in Table 43.1 was developed.

Training workers for specific jobs. Training work, although usually valuable, is always expensive, and it will not prove profitable on a large scale in small organizations, save for a very few highly specialized jobs. Such instruction merely modifies the previous training and experience of the worker in a way that will enable him to perform his tasks more effectively. Such training is a portion of the supervisory process and must always be carried on.

Inexperienced workers are continually applying for employment in tasks that require experience. Frequently these applicants can be eliminated by the employment department, but often they must be hired and tried because of the scarcity of workers. Figure 43.1 shows a very successful training school of the General Motors Truck and Coach Division. Each girl spent three days in this school before going out into production. Often workers, generally skilled in the trade, must be trained in a particular branch of it, if spoiled work, damaged machinery, or the risk of accidents is to be reduced to the minimum. Then, too, there are great potential gains in training workers already employed for advancement, and in training foremen and departmental supervisors toward a better understanding of the company and their jobs. These are the phases of a general training program, and they must always be developed with the present and prospective sizes and the general policies of the organization in mind.

[1] *Bulletin of Engineering Extension Division of Pennsylvania State College*

TABLE 43.1

Comparative Values of Different Methods of Instruction *

Types	I. Lecture	II. Textbook	III. Correspondence	IV. Individual Reading	V. Conference
Usual purpose	Inspirational and informational	Information on new subjects or additional knowledge	Promotion, increase of wages	Advancement and pleasure	Better performance on the job
Who determines subjects	Lecturer, with or without advice	Author or authors	Author or authors; purchaser of course	Man himself	Leader suggests; men dispose of subjects
Fitting subject to plant conditions	Probably no; possibly 100%	In a general way	Same as textbook	Possibilities greater	O.K.
Type of thinking promoted	Passive	Depends upon instructor	Active		Active
Chance to ask questions	No	Yes	Yes, by mail		Yes
Size of group	No limit	Usually smaller than lecture	One man	One man	16–20 preferred
Probable lasting effect	Very limited	Better than lecture	Similar to textbook	What he gets probably sticks	Better than I, II, and III
Faculty exercised by foreman	Memory	1. Memory 2. Ability to refer and apply	1. Same as II	Same as II	Thinking ability

* *Conference Leader's Manual* to accompany *Department Management* (Flint: General Motors Institute of Technology), reproduced by permission of Major Albert Sobey, Director.

Apprentice training. Apprenticeship as a vital part of the social and economic mores is not as common in industry as it was 30 years ago. Such training is found today only in fairly large plants, which, because of the great number of all-round workers that they need, can afford to introduce training courses and stand the expense of training workers who may not remain with them. Thus such companies as the Westinghouse

Courtesy, General Motors Truck and Coach Division

Fig. 43.1. Vestibule training school located in the plant adjacent to the regular workplace.

Electric and Manufacturing Company, the Goodyear Tire and Rubber Company, the General Electric Company, and the Ford Motor Company have found it profitable to develop apprentice courses. In these courses are enrolled young men and boys 16 to 18 years old or more who are trained for 3 or 4 years, paid wages for hours of instruction, as well as hours of production, and then at the end of the course are graduated as qualified journeymen and given in some instances $150 or $250 and their kit of tools.

A special feature that differentiates apprentice training from the training for operating a special-production machine is the attempt to teach the apprentice the underlying principles behind the trade. This instruction is immeasurably more fundamental than mere job training. There has been a revival of interest in apprentice training since the depression

of the thirties. For a while jobs were harder for young men to get, and the more ambitious ones turned to apprentice training as a desirable way out. The federal government has established a permanent committee on apprentice training, and employers have grown to realize that this program is particularly desirable in the training of men who will later develop into minor executives.

Vestibule schools. One of the most highly developed forms of industrial training is the "vestibule school," which teaches operations rather than principles. This is a preliminary-training shop especially designed for instruction, through which new employees are taken before being allowed to work on the production floors. This type of school attained particular favor during World Wars I and II because of the large number of workers engaged in occupations with which they had previously been totally unfamiliar. Sometimes this training takes place in a separate room and sometimes in the corner of the actual production floor, which is rather better when feasible, since it makes possible the immediate orientation of the new employee to the shop atmosphere of production (Fig. 43.1).

There are times when the vestibule school provides the best type of training, for example, when the job is unusually hard to learn, as contrasted with similar jobs within the industry, or when instruction seems to be impossible in the shop because of unusual conditions of production. However, it has many disadvantages, a few of which are as follows:

1. No matter how great the attempt, it is difficult to reproduce actual working conditions.
2. It is difficult and expensive to have sufficient machinery of each type in the plant set up in the school for instruction purposes.
3. Because of the uneven demand for new workers, usually either part of the vestibule school is idle, or workers are rushed through it without the desired training.
4. There is nearly always an adjustment period during the transition from the vestibule school to factory operations, especially if the worker spends long enough time in the vestibule school to be able to meet production standards. When the worker gets only the initial training in the vestibule school, this criticism is not valid.

Training the worker on the job in the shop. The most popular form of employee training is the instruction of the worker on the production floor while engaged in the regular processes of production. In training in this manner no additional equipment is necessary, but it is essential that the work be constantly checked to insure that training is actually being carried on. Such training is usually given by the foreman or under his immediate supervision. This is an ideal method of training under modern industrial methods, because the foreman, having been relieved of many of his previous duties, is left free for supervision and training, his

logical work. All foremen are not inherently successful teachers, but, if they have as complete a knowledge of their work as may be expected of them, they may readily be trained to impart their knowledge to others. The Training Within Industry (T.W.I.) Program and similar instruction for supervisors and shop instructors have raised the standards of instructing on the job. Foremen are often aided in the instruction of beginners by an assistant particularly designated for that work, if the department is large, or by designated workmen in a smaller department. Under the latter method it is necessary to reward the worker for giving instruction. Success will usually follow training under the foreman, if it is made clear that this is one of his chief duties, and if means are provided for following up workers to see that they are, in fact, receiving training and are not being left to drift.

Training for promotion. The need for training for promotion arises from the demand for men to care for an expanding program, as well as for the normal replacements necessitated by deaths, retirement, "quits," or other factors in expected labor turnover. Any promotion program which may be adopted by a concern cannot be allowed to rest with the development of line-of-promotion charts. Means must be provided for the training of deserving employees for tasks that are higher on the promotion scale. With the vestibule school this may be accomplished readily, and such a program allows for the utilization of this school during times when it might otherwise not be busy. Without the vestibule school it is necessary to sell the various foremen on the desirability of the training program and to follow up the program by accurate records to see that employees who are in fact successful are being prepared for advancement by their supervisors along the lines laid down by the promotion program.

The use of the system of understudies has been advantageous in some organizations possessing a high type of morale, especially when the organization is expanding. The understudy system requires careful follow-up, or it may exist in name only. Many workmen as well as supervisors are reluctant to train an understudy for fear that he will take the job.

Training supervisors, foremen, and subexecutives. Subexecutives hold a new and very important place in industry today. Upon them devolves the task of directing wisely the huge mass of industrial workers. To them these workers look for guidance and for an interpretation of the policy of the company. To the employee the foreman stands for the management of the plant. The development of modern industry from craftsmanship and small shops to machine production carried on in vast buildings—often only one group of a chain of enterprises under the same management—has automatically made the foreman the interpreter of the management to the men as well as the director of production itself. In

this dual capacity the foreman stands between management on the one hand and the rank and file of workers on the other—a peculiarly difficult and at the same time a powerful position. Among his responsibilities are the standard of production and the quality and quantity of work; indeed, upon him depend not only the stability and effectiveness of the industrial fabric, but also the fulfillment of the aspirations of thousands. In many respects the training of subexecutives is more important than the training of workers in the mechanical skills, because executive and supervisory abilities are relatively scarcer than mechanical abilities.

Much can be done to train these subexecutives for their tasks merely through the method of organizing the enterprise, as was explained in considering the committee idea in organization.[2] Much more can be done through intelligently handled plans of foreman and subexecutive training. Such training must primarily aim to develop the qualities of leadership of the foreman or subexecutive. It must broaden him and at the same time develop qualities of analysis that will enable him to visualize his job. One of the most important aims of such training must be to develop leadership in the foreman. Regardless of the formation and operation of a personnel department which will endeavor to win the complete confidence of the working force, it is but natural and desirable that a large proportion of the workmen will continue to look to the foreman as their leader and representative with the firm. Thus, the foreman should occupy a place in the esteem and confidence of the workers which cannot be duplicated by any artificial relationship that may be established.

Foreman and subexecutive training should encourage subexecutives to see the plant as a whole and to see their relation to it. Furthermore, it should so develop these members of the organization as to qualify them for advancement to positions of greater authority which become available.

Caution must be exercised in the methods of training which are used. The training must be carefully developed, lest it result in the swelling, rather than the growing, of those being trained. This unfortunate result is likely to follow unstinted reiteration of the great importance of the subexecutive to the business. Furthermore, if the inducement of advancement is held out by the firm as the bait to attract the subexecutive to the training, there is likely to be much disappointment when it is realized that, for every possible promotion that may exist, there are a number of trained candidates. Last, but not least, managements must be careful that they do not encourage the enrollment of their subexecutives in training courses advocating policies which the management is not

[2] See Chapter 6.

ready and willing to see carried into effect. It presents a sad situation to have the subordinate trained in scientific-management techniques which his superior spurns. Foremen, particularly, who receive this training and who find themselves both unable to advance to higher positions and unable to put into effect the methods which they have learned, are likely to develop a very bitter attitude toward those higher up in the management.

Two general types of subexecutive training have been developed, that which provides for discussions of methods, policies, and trends by the supervisory force of one plant at meetings held at the plant, and that which provides for enrollment in general groups of supervisors from a number of organizations. The first plan is by far the more desirable where it can be adopted, but small concerns, located in large industrial communities, will find much to attract them in the second method. In the one-plant groups an opportunity is provided to relate all discussions to the problems of the plant and the individuals who compose the group. Where such groups do not provide the training which is desired for any particular supervisor, such a person may be individually advised to join some general group or some particular home-reading course, trade school, or evening course. To secure the benefits of real training, however, it is essential that any groups organized within the plan be homogeneous, in order that topics of direct interest to all may be discussed. Several training groups may well be organized. If large groups composed entirely of executives are to be formed, it is necessary that the material discussed be confined to general subjects or to matter that involves the coordination of activities of nearly all those present. Such plant groups can often be handled to best advantage as part of a foreman's club or similar activity.

Group training courses, which are available in varying numbers depending on the size of the town in which the plant is located, and which may be recommended by the management, include Y.M.C.A. courses, university evening and extension courses, and courses maintained by groups of plants acting jointly.

The procedures used in instruction have been discussed on p. 565 under the heading, Methods of Instruction. The conference method is recommended as particularly suited for training foremen and subexecutives. The subject matter for most of the earlier phases of the training will be selected from actual problems arising in the particular plant, such as quality control, securing suggestions from employees, good plant housekeeping, accident prevention, the foreman as a leader of men, the foreman as a teacher. The more intimately these discussions are tied to the actual operations in the plant, the more profitable they will be. Such meetings, if properly led, will result in real foremanship training.

In addition to material relating to the functions of foremen and the manner of handling their work, general material on economics, the policies and history of the company, and problems of the industry are introduced in the most complete training programs (see Fig. 43.2).

The training supervisor. In large plants all training may well be placed under the direction of a supervisor of training, who may report

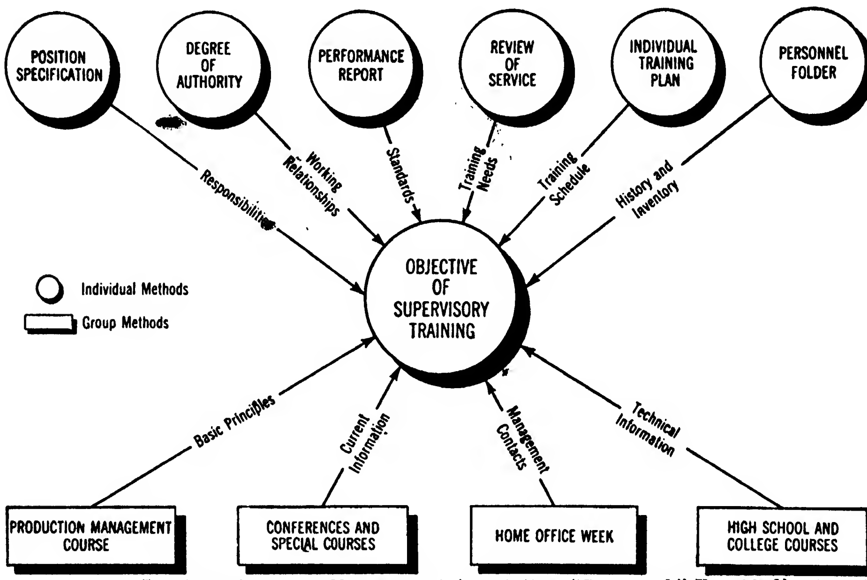
Courtesy, General Motors Truck and Coach Division

Fig. 43.2. A foremen's conference.

to the director of personnel. The director of training should be a man of executive caliber who has the proper background for training. It is a waste of money to have a \$200-a-month man try to train \$350-\$600-a-month supervisors. In smaller plants direction of training will probably be placed under the employment department or the service department. At any rate, it is largely a personnel function, although it deals intimately with production. In it are involved numerous major relationships of the management and the workers, including fitness for the job, promotion, and interpretation of plant policy. As such, it is primarily a personnel function, at least to the extent of follow-up. Actual instruction may well be in charge of the production force itself.

Figure 43.3 illustrates the methods used by Armstrong Cork in supervisory training. The circles at the top of the diagram represent training on an individual basis, and the rectangles represent group training.

Cooperation with universities and colleges. Many business enterprises that do not have active educational programs of their own encourage their employees to attend classes in the regularly established colleges and evening public schools of the community. In some instances this encouragement takes only the form of approval by the supervisor or personnel department by noting such attendance on the employee's record. In other



Courtesy, American Management Association, "Personnel," Vol. 23, No. 1, p. 18

FIG. 43.3. Graph showing supervisory training methods of Armstrong Cork Company.

cases the company pays a part or all of the tuition on successful completion of these courses. In some instances these financial aids are given only when the courses taken are such that they may reasonably be expected to increase the efficiency of the employee in his present job or aid in his preparation for promotion.

In some communities that have no regularly established evening schools employees are encouraged to take correspondence courses. Specialized correspondence courses may also be promoted even where regular schools are available. A word of caution should be made with reference to encouraging employees to take correspondence courses. A survey made by the Minnesota Employment Institute showed that only 6 per cent of the persons included in their study finished the course. Forty per cent gave up before the end of the first year, and approximately 75 per cent dropped out before the end of the second year.

CHAPTER 44

THE FOREMAN, A REPRESENTATIVE OF BOTH MEN AND MANAGEMENT

The foreman's position in the organization. In a very real sense the foreman is the directing head of an important economic unit.[1] It is true that his unit is intimately related to other departments within the enterprise, that his success is dependent upon the performance of other departments that precede his; but it is equally true that the departments that follow him cannot function effectively unless the work in his department has been properly executed. It is not unusual for a foreman in a large organization to have more men under his direct supervision than do plant managers in smaller institutions. The foreman must see that materials are available for his men, that men are available for the various tasks, that work is performed according to specifications and quality is maintained, that each worker turns out the quantity of work expected of him, that the machines are in proper working order and are operated in such a manner that they will give maximum life as well as maximum output. In other words, he is the general manager of his department. It is true that he may have staff or functional assistance in performing many of these duties, yet such aid does not wholly relieve him of his responsibility. A wise group of functional and staff officers will consult the foreman in making many of their decisions. As a matter of fact, the foreman in practice is required to give much of his time to aiding these staff officers. They relieve him of many details that he formerly had to care for, but he still remains an important person in the proper functioning of these specialized departments. By being relieved of some of the details, the foreman is enabled to exercise more effective leadership in his department. He is no longer required to be a first-rank specialist in many things, but he must be an all-round leader in various functions.

[1] Although the terms "foreman" and "supervisor" are used interchangeably in this chapter, practically everything that is said about them applies also to the office manager or the department head in any business, whether it be a department store, bank, public utility, or factory. In fact, most of the principles of scientific management, as developed in industrial management, are universal in their application with slight modifications to meet the peculiarities of the individual situation.

In large-scale industry the key man, as far as the worker is concerned, is the foreman. This fact is generally recognized, and most executive-training programs are basically built upon the training of the foremen. By far the most of these training programs are nontechnical, but they emphasize the leadership factors in a foreman's responsibilities.

Responsibilities of the foreman. An analysis of the foreman's duties will show that his responsibilities may be subdivided under three main headings: namely, to management, to the workers, and for materials and equipment, as follows:

1. To management.[2]
   - 1.1. To transmit faithfully managerial policies to the men.
   - 1.2. To transmit the worker's desires and aims to management. (This is a dual function. The foreman owes this responsibility both to the men and to the management.)
   - 1.3. To get out the required production on time.
   - 1.4. To maintain standards of quality by producing according to specifications.
   - 1.5. To formulate plans and methods to increase productive efficiency.
   - 1.6. To reduce all waste and scrap to a minimum.
   - 1.7. To keep accurate records from which future action can be guided.
   - 1.8. To render reports as required.
2. To the employees under his supervision.
   - 2.1. To provide adequate instruction in:
     - 2.11. Company policies and procedures.
     - 2.12. Correct methods of performing the required operations.
     - 2.13. The next job ahead, to enable the workman to be eligible for promotion if a vacancy occurs.
   - 2.2. To maintain satisfactory working conditions—cleanliness, order, safety, and an even flow of work.
   - 2.3. To maintain discipline.
   - 2.4. To promote cooperative effort and good will.
   - 2.5. To represent the workers to management.
   - 2.6. To promote and transfer impartially when opportunity presents itself.
   - 2.7. To rate the workers fairly for wage determination.
   - 2.8. To encourage suggestions and to give credit where it is due.
   - 2.9. To strive to fit each worker into the job for which his capabilities are best suited.
   - 2.10. To recognize individual differences and to provide inspirational leadership.
3. For materials, buildings, and equipment.
   - 3.1. To aid in the selection of material most suitable for use in the plant.
   - 3.2. To aid in the selection of the best equipment for a given operation.
   - 3.3. To handle materials efficiently so as to minimize waste.
   - 3.4. To use equipment according to the best practice.

[2] This tabulation is adapted from *Department Management,* Chapter 8, published by the General Motors Institute of Technology, Flint, Michigan, 1927.

3.5. To inspect materials, work in process, and equipment. (This does not take the place of the functional inspection of the other departments but is a part of the process of manufacturing according to established standards.)

The foregoing tabulation is largely self-explanatory and illustrates the magnitude of the foreman's tasks in spite of the various staff and functional aids that have been provided.

Some of the specific factors in which the supervisor represents management to the men are: (1) wages, (2) promotions, (3) assignment to a specific job, (4) safety, (5) layoffs and days worked, (6) recalls, (7) merit rating, (8) instruction on the job, and (9) working conditions.

The effect of the supervisor's attitude on his men. To a large degree *the men reflect the attitude of their supervisor,* and he sets the example for the feeling that the men have toward their jobs, their department, and their company. It cannot be said too often or too emphatically that to the men the supervisor is in a large measure the company. It is easy for the supervisor to forget this fact and represent himself, his attitude, and his feelings, rather than the company. Modern management strives to develop a working force of satisfied employees, and, in general, policies are directed to this end. Only when the supervisor recognizes his responsibility impartially to represent management to the men and carries out this responsibility to his fullest capacity can the company expect to have satisfied employees.

The supervisor has definite means at his disposal to meet this responsibility. First and foremost, the supervisor must set a good example, showing in his actions and his talk that he believes in the aims and the policies of the company and follows them as they are laid down. The supervisor who carries out the orders of management promptly and properly is setting a good example and is leading his men and his department toward cooperation with other departments and coordinating his department's work with the larger operations of the company. The supervisor represents management properly when he interprets orders to the men clearly and simply, giving explicit information about their work. When changes are made in methods, product, operations, or policies, the supervisor who is doing a good job in representing management carefully explains to the men, as far as possible, all the reasons underlying the change. In representing management it is always well to remember that the men want to know not only the *what* but also the *why* of a change in policy. The supervisor of today will do well to remember that the work group has undergone a change during the past twenty years. The men are, in many cases, younger in years but more mature in outlook. They are definitely better educated. Twenty years ago the high-school graduate

seldom entered the factory. Today the high-school graduate is found everywhere. The men are anxious to advance and with this aim in mind are studying their jobs, other jobs, the supervisor, and the company as a whole. Men today have a questioning attitude and seek the company and the work environment that they feel will satisfy them. In general, they are open-minded and willing to be convinced, but they must be "sold" by facts. The supervisor who is successful today bases his actions with his men on facts and utilizes these facts in leading his men to the combined objectives of the company, the department, and the individual employee.

The need for a balanced relationship. The foreman is hired by management and, as an employee of management, is naturally expected to represent its interests. Since the foreman's personal success is largely determined by the performance of the employees under his supervision, he is also charged with the responsibility of looking after their interests. This dual relationship requires a very high type of discrimination on the part of the foreman in order to discharge his responsibilities equitably to management and to employees, yet in the final analysis he is unfair to both parties if he unwittingly or otherwise fails to render justice to either one or the other. For instance, should the foreman, because of a special bias for management, fail to be fair in his treatment of his men, he is only piling up ill will and at times concealed grievances, which usually in the long run cost management much more in the form of strikes, restricted production, and large labor turnover than do the short-run gains. Viewed from this angle, the foreman is failing in his responsibilities to management as well as to the workers. The reverse situation is also true. Should a foreman fail to give management a square deal in production output or quality because of a misguided philosophy, he is working a long-run hardship on his men, for such conditions lead to an unfavorable competitive situation for the products of the manufacturer in the market (unless a monopoly prevails), which will reflect unfavorably upon the security of the workers' jobs. No person in large-scale industry exerts a more far-reaching influence upon the management-labor relationship than does the foreman. To many workers the foreman is management, or at least the only authoritative representative of management that they know.

There are well-defined practices that the supervisor may follow in keeping to the middle path of balance between the men and management. These practices include: (1) avoiding prejudices and striving to develop a judicial attitude in all matters where there is a conflict in interests, (2) continuously studying his men, (3) knowing the company policies,

(4) encouraging good will by manifesting it himself, (5) leading in teamwork, and (6) practicing loyalty.

As a group, modern foremen are technically skilled in the mechanical processes. Many of them have served as workmen in the departments which they supervise. It might reasonably be supposed that they have the viewpoint of the worker. As far as the worker's reaction to turning out units of production is concerned, this supposition is undoubtedly true. When it comes to methods of supervision, however, foremen tend to follow the practices used by their supervisors when they were workmen.

Some practical aspects of foremanship. Often foremen are not emotionally stable in certain aspects of their personalities, and frequently they suffer from inferiority complexes. This feeling of inadequacy may be concealed under normal relationships but become active when the men are faced with responsibility and authority. The result is an obnoxious display of authority to cover up the real inner feelings. A man possessing ability, confidence, and a knowledge of the principles of leadership will *studiously avoid all displays of authority and will use it sparingly.* When a foreman has to fall back on his authority to get a thing done, he may be sure that his real leadership is being questioned.

In personal contact with his men the foreman should be perfectly natural. He should avoid undue familiarity, yet not give the appearance of "stand-off-ishness." This is especially true of the young foreman who may have many men in his department who are older than he is. The foreman may well show a personal interest in his men but must avoid prying into their private affairs.

Under most unexpected circumstances a foreman will have his sense of fairness questioned. Every semblance of partiality should be avoided. Such items as fraternal allegiance, church membership, and nationality preference may easily give rise to an unfounded charge of favoritism. It is hazardous to have only two nationality groups or fraternal groups in a department, particularly if the foreman belongs to the predominant group and the other group is large but in a minority. If such a situation exists, the foreman should urge the employment department to make most replacements from a third group until a better balance is obtained. Nepotism gives rise to charges of favoritism that no foreman can easily overcome.

Authority and responsibility. Sound organization requires that a foreman be clothed with authority commensurate with his responsibility. Any other situation not only tends to destroy the effectiveness of the foreman but also weakens the morale of his entire department. A few men are not temperamentally suited to be invested with authority.

The foreman's position in the organization implies that he is responsible for the conduct of his department. To be known as a real leader he must willingly assume this responsibility in stormy weather as well as in calm. The foreman cannot shift the responsibility to the shoulders of his subordinates, for he is responsible for their performance also and has failed in the discharge of his duties if he has not followed through to see that his department as a whole has functioned properly. The foreman who frankly assumes the responsibility for his department and gives credit to his men for successful performance places himself in an advantageous position for leadership.

In connection with the foreman's discharge of his responsibilities, a condition is arising in industry that has not as yet been satisfactorily solved. It is the tendency of labor leaders to by-pass the foreman and superintendent and to go direct to the top management with their problems. This situation has been complicated by top management's failure to take the foreman completely into their confidence regarding the details of these conferences with the representatives of labor. As a result the position of the foreman has been weakened without his being relieved of his responsibilities. As it stands, the situation in many instances is untenable.

One step to strengthen position of the foreman has been management's consulting with him, before beginning negotiations for a new contract, in order to secure his opinion of how the current contract has worked. A second step has been the requirement that the foreman be given the first opportunity to handle a formal grievance. A third step that will correct the situation is for management to give important information to the foreman as quickly as the union gives it to the workers. This is not always easy to do, but it is possible if enough energy is put behind it.

Promotion of cooperation by the foreman. Cooperation within the department usually reflects the attitude of the head of the department. If the foreman would receive cooperation from others, he himself must give it freely. The foreman who strives to aid his men in the realization of their personal objectives may reasonably expect cooperation from them. When a foreman realizes that he cannot offer merited promotion to one of his men because there is no vacancy in his department and goes out of his way to aid this man to get promotion elsewhere in the organization, his workers will soon learn of it with a resultant rise in morale. On the other hand, should a foreman block the transfer of one of his men to a better position in another department because he does not want to go to the trouble of training another man, it will be difficult to keep this information from the men, with a resultant attitude of "What's the use

of trying, anyway." Interdepartmental cooperation is merely an extension to other departments of the attitude existing within one.

Mass production demands complete cooperation between departments in the processing and moving of materials from department to department as rapidly as possible. In such an industry the supervisor must see that as rapidly as his department finishes work on the product it is moved without delay to the next department. On the other hand, he must be certain that the material he moves passes inspection and will be satisfactory for use in the next department. If staff departments, such as production-control or inspection, are working with the supervisor, he must give them his fullest cooperation in making their work effective. In this respect he is again cooperating with the departments following him because these staff departments must service the product before it can leave his department. When unavoidable shortages of men occur or overloads on departments develop, the supervisor may be called on to lend men to other departments. In such instances the supervisor cannot send his least capable men, for, if he does, he can expect retaliation when it becomes necessary for him to borrow men because of shortages or other difficulty. The wise supervisor soon learns that he gets only what he gives, that cooperation is a two-way process. When the men see that the supervisor willingly cooperates with other departments, they will usually cooperate with him.

The foreman and the National Labor Relations Act. The foreman is considered by the National Labor Relations Board to be a representative of management as far as his actions relative to his men's membership in a labor organization are concerned.[3] The only safe policy for the foreman in respect to the union membership of his men is strictly "hands off."

Aside from any action of the foreman that may be interpreted as interfering with the free choice of the worker of union membership, the foreman may do anything that he could before the passage of the act. He is, however, under the responsibility of guarding his actions so that they may not be misinterpreted months later by an inquiring representative of the National Labor Relations Board. Consequently the foreman should make more records of the causes for his actions than he formerly did. A failure to make accurate records with names of witnesses and causes for action may become exceedingly embarrassing later. The foreman must studiously avoid any discrimination among his men because of union membership. When he is in a position to demonstrate that he

[3] See Russell L. Greenman, *The Worker, the Foreman and the Wagner Act,* Harper and Brothers, New York, 1939, pp. xiii–xvi.

has so acted, he may continue to run his department along as sound managerial lines as formerly.

For several years an argument has been raging regarding the advisability and right of foremen to be members of a union themselves and to engage in collective bargaining with management. For many years some foremen in the skilled trades have been members of the same union as their men. In mass-production industries foremen have not been active in unions of their own or of their workers. As a whole, management prefers to deal with its foremen as management's representatives and finds it difficult to see how a foreman can owe allegiance to a union and at the same time represent management in dealing with the same or other unions. As our book goes to press, the National Labor Relations Board has recognized the right of foremen to belong to unions of their own choice should they desire to do so. Relatively few foremen, however, have signified any special interest in union membership. If management treats its foremen as a part of management, the unionization of this group is not likely to spread.

CHAPTER 45

ORGANIZED LABOR AND MANAGEMENT

The personnel director and collective bargaining. The National Labor Relations Act of 1935 definitely establishes the right of workers engaged in interstate commerce to collective bargaining with their employers through representatives of their own choosing. By the broad interpretation of "interstate commerce" most industry comes under the provisions of the act. Organized labor grew gradually in strength during the thirties, but its development during World War II was almost phenomenal. Even the most biased advocates of unionism can no longer talk about the weak position of labor at the bargaining table.

In view of the widespread acceptance of collective bargaining it is but natural that the personnel division should become involved. Many companies call their personnel division the industrial-relations department or division. In some cases this practice has come to signify that organized labor contacts are included among the varied functions of the personnel division.

It is difficult to generalize concerning the part that the director of personnel or industrial relations should play in organized labor-management relations. There is little doubt that the personnel director should take an active part in trying to make a union contract work. He is nearly always one of the persons to whom appeals are made in the course of handling grievances and is frequently the chairman of the Appeals Committee, the last step in the grievance procedure before the final appeal to top management.

It is highly important that the contract should be clear in regard to all details covered. The personnel manager strives as far as possible to adhere to the spirit of the contract rather than technicalities and so advises both management and the union. On the other hand, he should studiously avoid being a party to amending the contract through the grievance procedure. One of the favorite tricks of aggressive union leaders is to sign a contract and then strive by interpretation and grievance procedures to modify it so that it becomes the one they wanted in the first instance. Such amendment, on the part of either the management or the union, is a very poor practice. Both parties should strive to live up to both the spirit and the letter of the union contract.

Should the personnel director or his representative negotiate the union contract? Since wages are a primary part of any union contract and are, in most instances, one of the largest elements in costs, the union contract should be negotiated by a representative of operating management. The union contract sets a basic policy in terms of costs. The operating management may determine certain limits within which the wage level may be permitted to fluctuate and delegate to the personnel director the responsibility for negotiating the contract within the established policies. Such a procedure relieves top management of a laborious, time-consuming detail but does not encourage real collective bargaining, since the union leaders soon recognize that the personnel director's authority is limited. It must be frankly admitted that some top-management men are not qualified by temperament or experience to engage in collective bargaining with the skilled union negotiator. In such cases it is imperative that the personnel director or some other representative serve instead of the operating manager. Nevertheless, contract negotiation is a top-management job, and the responsibility for it rests squarely upon top management. When the personnel director performs this function, he should be given the rank of a vice-president of the company, for prestige in dealing with the union if for no other reason. One other fact should be remembered: the director of personnel is not in so impartial a position to aid in making the contract work if he negotiates it. For this reason and others some large companies have established a separate labor-relations department which negotiates union contracts and reports to the general manager. This is usually a small department, since the volume of work is not large, even though very intense for a period. Of course in many cases operating management negotiates the contract with the consultive advice of the director of personnel.

Working with the union. On the assumption that a given union or several unions have been recognized as the representatives of the workers, and a duly signed contract is in force, what is left to be done? The contract usually establishes the wage level or brackets, but frequently discretionary decisions must be made. There are also many subjects, such as safety, suggestions, waste reduction, quality of product, apprentice training, recreational activities, medical service and first aid, cafeteria, and similar activities, that may be handled solely by management or cooperatively with the union representatives on an informal basis, even though they are not included in the contract. If the company has practiced cooperative supervision of these activities, it is likely to continue to do so, provided that the organizing campaign has not developed undue bitterness. Many of these items are handled cooperatively in companies that have had long experience in union-management relations. The gen-

eral attitudes of the union and of management largely control the extent of this collaboration, particularly true in connection with waste reduction, methods improvements, suggestions, worker efficiency, and similar matters. It will be well to examine some of these traditional attitudes, since the present is largely an outgrowth of the past, particularly in respect to sentiments concerning the restriction of production.

Management's attitude. Before the National Labor Relations Act (the Wagner Act) was passed, employers as a group in most large-scale mass-production industries were actively opposed to collective bargaining with an outside labor organization. Until April 12, 1937, when the Supreme Court upheld the constitutionality of this act, there was much opposition to bargaining with labor unions, although a few key industries, such as some of the automobile manufacturers and big steel companies, had signed contracts with affiliates of the C.I.O.[1] In those industries which are sufficiently organized to support trade agreements, it has been seen that organized labor and management are now operating at the individual plant level with relatively little friction. When the annual contract comes up for renewal, such as in the bituminous coal industry, the entire industry may be shut down until the terms of the contract are settled.

Anyone who has attended management meetings for the past ten years cannot fail to be impressed by the change in attitude of managers toward collective bargaining. Before the approval of the National Labor Relations Act by the Supreme Court most managers in mass-production industries definitely preferred to deal with their employees on an individual basis or with their employees' representatives from within the company. The National Labor Relations Act encouraged the development of unions whose membership was not confined to an individual plant or community. Respect for the court's decision has contributed greatly to the changing attitude of managers whose sentiments had been built up over years of operations. The cynic may retort that managers *had to comply* with the court's decision. This, of course, is true, but it alone does not account for the basic change in managerial attitude. Although most managers may still prefer to deal with their own employees, they have entered wholeheartedly into collective bargaining with unions of their employees' choice. Some managers prefer to deal with a responsible national union rather than an independent company union.

One must never construe a manager's failure to acceed to an excessive union demand for wage increases that will force up prices as an unwil-

[1] Congress of Industrial Organizations, formerly Committee of Industrial Organization, is a federation of industrial unions in contrast to the A. F. of L., which is composed largely of craft unions.

lingness to bargain collectively. The demands for a 30-per-cent wage increase that resulted in a wave of strikes in 1945–1946 were resisted on this basis. An increase of a little over half the demand resulted in substantial price rises all over the nation. In analyzing union requests and managements' responses moderation is needed in fixing the blame for strikes. It is perfectly natural for a union in one industry to try to get a larger share of the total national income, even though its action directly increases the price of the commodity to the public. This was the situation in the coal strike of 1946. On the other hand, it is equally to be expected that management will consider the economic results of increased costs, particularly when there are substitutes for its product, such as oil and gas for coal.

Early organized labor's reaction to scientific management. The early opposition of organized labor to modern management's principles and devices was based partly on economic principles, since repudiated, and partly on a misunderstanding of its basic concepts, arising out of the improper wording of the first scientific-management writings. Notwithstanding his many denials, it is probable that most union leaders who were contemporaries of Frederick W. Taylor thought that he was an enemy of unions. In Taylor's day many unions favored restriction of output, a concept to which Taylor's whole life was opposed. Today many groups in organized labor in the United States agree that in increased output lies the opportunity for higher wages.

It was probably due to the fact that scientific management first developed in unorganized trades that union leaders of the time feared it and endeavored to destroy it. They particularly attacked time study as the device which they claimed was symbolic of the attempt of scientific management to destroy skill and initiative. Against time study organized labor made a great drive in Congress in 1912 at the hearings before a special committee of the House of Representatives "to investigate the Taylor and other systems of shop management." Stop-watch time study had been adopted in the arsenals of the Army Ordnance Department through the leadership of General William Crozier, Chief of Ordnance. It is probable that more persons were working under rates set by time study in the government arsenals in 1912 than in any other enterprise. It was the example of the use of the stop-watch in the new and unorganized automobile industry, however, that led the unions to try to destroy its use nationally by prohibiting it in government work.

It was during these hearings that Taylor was put on the stand and said:

> Do not understand for a minute that I am opposed to trade unions. . . . I am in favor of them. They have done a great amount of good in this country

and in England; I am heartily in favor of those elements of trade unions which are good. . . . I believe that the unions are misguided in a few respects. . . . One of the worst principles of the trade unions . . . is that it is to their interest to deliberately, purposely work slow instead of working fast, with the object of restricting output.

Taylor's attitude of yesterday has become the attitude of *enlightened* union leaders of today. It will be observed that this last statement emphasizes *enlightened* leadership. Unfortunately all union leaders, as well as managerial leaders, are not enlightened. There still are many cases of deliberate restriction of production or output.

Labor's attitude concerning time study. In 1912, under the pressure of labor-union lobbying, Congress wrote into an appropriation bill a provision that forbade spending of federal funds for time study in certain governmental departments. This opposition to motion and time study still prevails in large segments of organized labor, but it is by no means universal. Several unions have used the technique of time and motion study as an aid in fact finding to strengthen their position in collective bargaining; some unions maintain industrial-engineering departments to represent them in establishing standards for piece work or to aid an employer who is having trouble in meeting competition. The Amalgamated Clothing Workers have an excellent industrial-engineering department.

The published attitudes of three unions regarding scientific management techniques in summary form are given below:

1. The Steel Workers' Organizing Committee in Publication No. 2, *Production Problems* (1938), p. 10, states its position as follows:

> There is often dispute between management and men as to what is a fair day's work. Men may complain of speed-up. The management charges that the men are lying down on the job. The way to settle this kind of dispute is to set production standards by agreement.
>
> How is this done? First make sure that tools, materials and work are assigned so that work flows through the shop with little interruption. Then take a man doing a given operation and tell him to work at his ordinary speed, without soldiering on the job, but still in a way that is not too fast to keep up without strain or fatigue. A representative of the union and a representative of the management should watch him and measure his speed. There are various ways of doing this that provide the required accuracy and precision.[2] There should be agreement about the results by both sides. Observation may be repeated several times, or made for a number of men doing the same job. On the basis of the records obtained, *and after* consultation

[2] Those familiar with these methods recognize time study by the use of a watch or by the use of a motion picture as two of the most practical methods. A third method is the use of elemental times if they have been accumulated. (This footnote is the author's and not a part of *Publication No. 2, Production Problems*.)

with those doing the work, it may be agreed how long it ought to take to do the operation in question, and how many times it ought to be done per hour or per day. Such an agreement then is adopted as the *production standard* for the job in question. . . .

2. Emil Rieve, president of the American Federation of Hosiery Workers, writing in the February, 1939, issue of *Labor Information Bulletin*, p. 6, states:

> One of the most important features in the union's agreement with the Full-Fashioned Hosiery Manufacturers' Association has been the operation of an impartial adjustment machinery. The impartial chairman who is selected by the union and representatives of the manufacturers, handles all grievances that cannot be satisfactorily settled by direct negotiation. He is also responsible for making wage studies and for helping to fix wage rates as new technical developments occur in the industry. Wages are based upon complicated piece rates which vary with the skills required, speed of machines, amount of hand labor involved, quality of silk, and numerous other factors.

3. Anne Gould of the International Ladies' Garment Workers' Union in an article entitled "Fixing Wage Rates in New York Dress Industry," in the April, 1938, issue of the *Labor Information Bulletin*, p. 2, reports:

> Several years before the old agreement expired the Dressmakers' Union hired a number of industrial engineers to study the labor factor of the industry with a view to reduce the various jobs involved in making dresses to measurable units. This study resulted in the unit system, which is a method of expressing the average time required for each operation in the making of a given dress. By this method the job-time units for certain operations which are common to all garments have been established. The unit system is today used as the yardstick by which piece rates are determined because the tremendous style variability makes standardized piece rates impractical.

It is evident that there are some marked contradictions among labor leaders regarding the use of the tools of scientific management. The objections of labor to time study may be classified under these main headings: objection because of its effect on the status of the individual workers, objection because of its effect on basic union policies, and objection because of defects of method.

The traditional opposition voiced by some unions to motion and time study. It has been pointed out by many workers that to take time studies is, in a sense, evidence that management is suspicious of the good intentions of the employee to turn out a fair day's work. It is contended that management would never think of taking time studies of executives in the performance of their jobs, but that more opportunity is usually afforded for improving their output than for increasing that of the worker.

The answer to this objection, as to most others, depends on the methods of taking the study, the extent of cooperation of the worker himself, and the benefits which the worker receives.

It is also pointed out that time study is destructive of the worker's skill, inasmuch as it substitutes the skill of the management for the acquired trade skill of the worker. Not only may this situation result in the degradation of the worker, but also it is to be questioned whether it is desirable from the broad social standpoint to allow one small class in the industrial community to have all the knowledge concerning how jobs should be done. It is pointed out that, after job studies, workers must conform to the methods of others. Of course the answer is that, although it is true that all workers are taught the one best method known at the time, it is not true that they are prevented from improving upon this method; rather, they are encouraged to do so.

It has frequently been said that, although rates under job study may be guaranteed, time study becomes a method of cutting wages. The reasoning is that the reservation is always made, when guaranteeing wage rates, that a change in the method of operation may result in a change in the rate. Since the method is so clearly and closely detailed by the result of job study, it becomes exceedingly simple to change the operation in some slight degree. This change may be brought about because workers may have been getting high wages through close application to their work under the assurance that rates would not be cut. If the operation is slightly changed and the new rate which is set is sufficiently below the old one it will be necessary for the worker to apply himself at the same pace in order to receive considerably lower wages. Again, the only answer which can be made to this objection is that management should be as honest in setting standards of production as in establishing standards of quality. As a matter of fact, management frequently overlooks a series of improvements, each small within itself but cumulatively resulting in a changed condition, that enables the worker to increase production as much as fifteen or twenty per cent with no increased effort. This practice is misguided. Standards should be carefully kept up to date at all times, but there is absolutely no place in scientific management for any questionable practices.

Time studies do not develop class consciousness. Traditional trade unionism is based on the idea of the development of class consciousness among workers. It is alleged that this attitude is necessary in order to combat the superior economic position of employers, particularly organized employers. Time study, which results, to an extent, in competition among the abilities of the individual workers, naturally has a tendency to break down this class consciousness, particularly since the rates based

on time study ordinarily are piece rates or some variation of them. Traditionally unions in general have not been very favorable toward piece rates or incentive systems. As has been pointed out, however, there have been some very successful unions that have adopted piece work as their system.

It is probably true that a study of jobs within an organization has a tendency to knit the organization into a unified whole of management and workers, all striving to improve the general condition of a particular plant rather than of any specific group in industry as a whole. In so far as this is true, it is but natural that organized labor should look with some degree of alarm upon time study, particularly since this situation is contrary to one of the basic ideas behind the development of unions. On the other hand, the adoption throughout an industry of standardized piece rates, as in the International Ladies' Garment Workers' Union, builds up the same unity among the group as the flat day rate and prevents to an even greater degree exploitation by a few employers.

Union advocacy of low production costs. There is an increasing tendency for intelligent labor leaders to advocate efficiency in production to make possible the lowering of costs and prices. William Green has said:

> Labor realizes that the success of management means the success of labor. For that reason labor is willing to make its contribution to assist management and to bring about the right solution of problems dealt with by management. . . . Management is understanding more and more that economies in production can be brought about through the cooperation of labor and the establishment of sound labor standards rather than through autocratic control and the exploitation of labor. Labor is understanding more and more that high wages and tolerable conditions of employment can be brought about through excellency in service, the promotion of efficiency, and the elimination of waste.[8]

Edward T. Cheyfitz, National Chairman of the Casting Division of the C.I.O. Mine, Mill, and Smelter Workers, writing in the December, 1944, issue of *Fortune* under the title "More for Less," stated:

> The test of union survival, and for that matter the survival of our nation as presently constituted, lies in the momentous question as to whether in postwar America management and labor can find a common ground. That common ground lies in jointly pursuing the high road of production. Labor unions are here to stay if they realize that they must fit themselves into this general pattern. Progress and high productivity will be synonymous in our postwar society. Apply this to labor's job, and it resolves itself into a positive stand by labor for "no shackles on production." The future of American unionism can be assured by its support of industrial efficiency.

[8] William Green, President, the American Federation of Labor, "Labor's Ideals Concerning Management," *Bulletin of the Taylor Society,* Vol. X, No. 6.

There is not the slightest question regarding the sincerity of Mr. Green and other labor statesmen. The tragedy is that at the work level, where increased efficiency is achieved, these statements are accepted for the other fellow, but not wholeheartedly by the particular group. For instance, in Mr. Green's own A. F. of L., the building trades unions are notorious for their opposition to the introduction of scientific-management procedures that would increase production. The Railway Brotherhood likewise is noted for "feather-bedding." An occasional union leader at the local level speaks out in favor of a full day's work for a fair day's wage. Such incidents are heartening, but they do not by any means represent the prevailing situation. It is easy to understand that workers fear losing their jobs when fewer men are required to do the same work. It is difficult for workers and many others to take the broader economic and social view that the production of more goods at a lower unit cost will raise the standard of living of all persons. Most of the marked improvements in production have been made by management. The unions are in a position to make outstanding contributions in this field if they can get the statesman-like attitudes of their top leaders to function at the work level. Forebearance instead of name calling is needed to enlist the cooperation of the men who do the work. Employment-stabilization programs in those industries that can inaugurate them will remove some of the causes of the general fear behind the hesitancy of worker groups to increase efficiency. It should not be concluded that no improvements come from the workers. Many of them do originate with individuals, but this is quite a different matter from organized group action to achieve the same purpose. On the other hand, there have been effective union efforts toward waste reduction and increased productivity. It must be borne in mind that there is not one union but many unions, each largely governing itself.

The National Labor Relations Act and the worker. The main objective of the National Labor Relations Act, after being stripped of all surplus verbiage, is contained in its statement of purpose: it is the guarantee to the workers of the right to organize into groups of their own choosing for collective bargaining. In this respect the act gave the workers nothing new. It did, however, provide them protection against discharge as a result of exercising this right to membership in a union. Under the act an employee is protected against discrimination because of his union membership. He is further protected from the annoyance of any attempt by the employer to influence his choice of union. The act does not protect an employee from annoyance, intimidation, or violence from a particular union seeking his membership or dues.

As the act was formerly interpreted, the employee was denied the counsel of his employer regarding a union should he seek it during an organizing campaign. On the other hand, recent decisions of the Supreme Court have restored to the employer certain freedom of speech that formerly was definitely denied him by the rulings of the National Labor Relations Board. The individual employee has practically no rights under the National Labor Relations Act unless he is a member of the majority bargaining group. Section 9a states in part that ". . . any individual employee or group of employees shall have the right at any time to present grievances to their employer." The Supreme Court's decision in the Hughes Tool Company case reduced this clause in the law to an idle gesture when in substance it stated that an individual or group could present a grievance but the company could not hear the complaint nor decide the question unless the union representative was present, provided that he desired to be. The act sanctions a closed shop if a majority, acting through their recognized bargaining agency, can persuade the management to approve such an arrangement.

The National Labor Relations Act and the employer. The National Labor Relations Act, sometimes called the Wagner Act, was designed to protect the employee in his right of collective bargaining. It confers no rights upon the employer; however, it takes away from him no rights that he should have ever exercised from the standpoint of long-run industrial statesmanship or social and economic well being.

It should be noted that the limitations on the employer's acts apply only to those activities that may be interpreted as having a bearing upon union membership or collective bargaining. The employer is required to bargain in good faith with the union that represents his employees, but there is no similar requirement that the union bargain in good faith. It may be argued that the union always bargains in good faith, but experience during World War II and under the Railway Labor Act has definitely demonstrated that such is not always the case. The employer is helpless when two unions are fighting for the membership of his employees. His plant may be shut down by such a struggle. Even though the National Labor Relations Board certifies one union, the loser may picket the plant. The employer also has no recourse in a secondary boycott.

Under the act the employer still may hire any man of his choice (provided that he does not have an agreement with the union to the contrary), promote the man he desires, or discharge a man for cause—other than union membership. In other words, under the National Labor Relations Act itself, the employer is restricted in no activities other than those affecting collective bargaining. In the board's efforts to make the law

effective it has gone to some extremes that do not seem necessary, even to many friends of the act. The Supreme Court reversed the order of the board in the case of the Fansteel Metallurgical Corporation, when the board sought to force the company to rehire some sit-down strikers who were legally discharged. It is to the credit of the board in this case that it did not justify the sit-down strike but claimed the right to take the steps it ordered as a method of enforcing the provision of the act

CHAPTER 46

EMPLOYEE-EMPLOYER COOPERATION

Employee-employer cooperation defined. In this chapter cooperation between employer and employee is thought of as cooperation over and beyond that required by the formal organizational structure in the achievement of the general institutional objectives. This cooperation may be at either a formal or an informal level. Participation has meant at times a share in the profits of the enterprise, but more correctly, and increasingly, it has meant an employee voice in the determination of management policies in so far as they affect employee interests. There has never been found so great an incentive for carrying on industry as private ownership and the mental attitude toward private property owned or to be acquired. Employee participation in management seeks to extend to all members of the enterprise such a share in its operation that the satisfactions of private ownership will be extended throughout the working force. It is the hope of the advocates of employee-employer cooperation to develop a feeling of *oneness*, a recognition of mutual interest, and a desire to carry on which is frequently described as "loyalty to one's own best interest." This is undoubtedly an optimistic approach, and the results are seldom fully realized, yet the efforts in this direction mark a distinct advance in labor relations.

Profit sharing.[1] The oldest form of employee participation is direct sharing in the rewards of the business. In substance this was practiced in the days of an agricultural economy when the tenant cultivated the soil on the "shares" basis. This practice still prevails in our rural sections today. Fishermen also share the fruits of their "catch." In industry the "sharing of the crop" idea has been supplanted first by a financial wage and later in some instances by a wage plus a financial share in the profits of the enterprise, either through some developed plan of profit sharing or through "melon cutting" at the end of prosperous years. Profit sharing, in its most acceptable form, implies an agreement between the employer and the employees, under which the workers receive, in addition to their wages, a predetermined share in the profits of the

[1] See Senate Report No. 610, 76th Congress, 1st Session, *Survey of Experiences in Profit Sharing and Possibilities of Incentive Taxation.*

undertaking over a given period. Under this form of profit sharing an employee knows at the beginning of a year that he is going to secure some predetermined share of whatever profits there are at the end of a year.

The distribution of bonuses at Christmas or other times of the year, in the attempt to share with employees the profits of the enterprise over the period, has not usually proved a successful form of employee participation. As a matter of fact, there is serious question regarding the advisability of giving the employee profit-sharing payments in cash when they are substantial. This statement, of course, does not apply to such small payments as $25. The employee who receives such payments regularly soon begins to look upon them as a part of his wage and frequently spends them in anticipation of receipt. When profits are not earned and hence cannot be distributed, the morale effect is likely to be bad, since the employee may have worked just as hard as when he received a substantial payment the previous year. A much better policy is to pay employees their share of profits in the form of a paid-up annuity. This helps the employee build up his estate and will make an income available to him when he will no longer be earning wages. It must be clearly understood that profit sharing is not a substitute for paying the prevailing wage for a particular occupation.

Profit sharing is often used as a means of arousing the interest of workers whose jobs are such that it is difficult or impossible to place them upon piece work. Such men are executives, delivery men, men in the shipping room, and, at times, salesmen. Then again, by arousing the sense of participation, profit sharing is frequently used for some specific purpose in the business. Thus it may be used to prevent the waste of materials, as it is when a concern agrees to split "fifty-fifty" with its employees any saving of material which they effect. Many managers regard profit sharing as an ideal way to reduce labor turnover, by providing that only employees of a certain minimum length of service will share, and that these will share in accordance with their length of service. Any philosophy of tying profit-sharing to programs that have as an objective the weakening of collective bargaining is open to serious question. Labor unions have as a rule not been advocates of profit-sharing programs.

One of the main objections that employers have raised to profit sharing is that it does not in reality involve financial participation, inasmuch as losses are not shared by those who share the profits. This unquestionably is one of the weaker points in any profit-sharing plan, but its importance varies with the basic thinking which has prompted the plan. Thus some employers have come to feel that there is a wage for capital, just

as there is a wage for labor, and that, in justice, all earnings above a certain wage for capital should be distributed between capital and labor. Under this assumption there would be no cause for workers to share in losses, provided only that some provision were made for their repayment before the workers again began to share in the profits.

Management's objectives in profit sharing may be summarized as follows:

1. To promote individual efficiency.
2. To promote general efficiency.
3. To develop a waste-elimination consciousness.
4. To encourage managerial efficiency.
5. To develop a proprietary attitude on the part of employees, thus contributing toward the preservation of private capitalism, since a worker will not be likely to embrace an "ism" that takes away from him his own rights in private property.
6. To provide a measure of security for employees.
7. To reduce labor turnover.
8. To foster industrial democracy.
9. To encourage mutual cooperation and understanding between the employer and employees.

Employees' reactions to profit sharing. Since practically all profit-sharing programs have been initiated by management, the question naturally arises: How do the employees feel toward profit sharing even before having tried it out? In order to test the sentiment of labor concerning this subject, questionnaires were mailed to a large and representative number of employees of each of 104 industrial plants throughout the United States, employing, in all, approximately 90,000 men, none of the establishments having a profit-sharing plan in operation.

The replies indicate conclusively that the workers, far from being opposed to profit sharing, are strongly in favor of it and that the majority have some appreciation of the problems of capital and desire to be fair and reasonable. The responses also indicate that a large portion of labor is more interested in providing for the future than in having the funds available for immediate disbursement.[2]

Employee stock ownership. The investment of profit-sharing funds in stock of the corporation has in the past been one of the more usual features of profit-sharing schemes. Such a program leads to direct participation in management. Any such plan should be carefully guarded and explained to employees concerned, particularly as regards a possible decline in the market value of the securities. Furthermore, unless the num-

[2] H. R. Rietz, Vice President, ILG. Electric Ventilating Company, quoting the Senate committee investigating profit sharing in the United States, in a speech before the Industrial Management Society, April 7, 1939.

ber of shares which a given employee may own is considerable, the plan tends to become one for investment of the surplus funds of the employee, rather than of participation in management. This fact is indicated by the tendency of employees to sell stock, if it is in their control, when the market begins to decline. A serious objection to worker ownership is the fact that it frequently operates in direct opposition to security.[3] If the worker is laid off for a long period because of reduced production, this layoff will usually happen at a time when the value of his stock is declining, as well as during a period when the dividend return is low. Such a procedure also lacks the desirable characteristic of diversity.

The foregoing statements lose some of their force if the stock is given to the employee outright as a part of a profit-sharing program with the understanding that it is to be held as a long-run proprietary interest in the company. Some people have advocated the issuance to employees of special nontransferable stock that has all the rights of common stock save transferability. Under such a system, if an employee retires, he is permitted to exercise the option of exchanging his stock for regular common stock or selling his stock to the company at the current market price.

Stock-ownership plans are more successful as means of participation among salaried officers than wage-earners, as the officers are usually better able to understand the benefits of ownership and are usually in a position to own sufficient stock to arouse their enthusiasm for the scheme.

Employee representation—works councils. The objective of employee representation is to substitute cooperation in operations for the antagonism that has frequently arisen in employer-employee or management-employee relationships. Frequently cooperation can be achieved without employee representation, but this relationship is presumed to furnish a condition wherein cooperation is promoted on both sides. Usually cooperation follows when management shows the representatives of the workers that the employer has the interests of the employees at heart. It frequently is necessary for some time to elapse before employees are convinced that the employer sincerely desires to work with their representatives. Then a longer time is often necessary, after the plan has begun operating, to convince both sides that their interests are similar as far as effective operation of the plan is concerned.

Works councils provide a means for representatives of the employer and those of the employees to get together and discuss matters of common concern. They are formed on the basis of agreements between an employer and his employees and differ from trade agreements or agreements

[3] See Eleanor Davis, Industrial Relations Section, Princeton University, *Employee Stock Ownership and the Depression,* 1933; also Helen Baker, *Employee Savings, Stock Ownership, and Profit Sharing,* 1937, for a detailed discussion of this subject.

between an employer or employers in a given industry and organized workers within the industry as a whole. Works councils consider questions of shop rules and grievances, and in addition they often handle matters of efficiency of operation and economies and at times of policies. Works councils organized for the first of these purposes are likely to develop mutual respect and confidence between the interested groups and gradually extend their activities to include the broader economic operating phases.

At professional meetings of management men the question is frequently asked, "How can you have an organized grievance procedure when you have no union?" The works council provides an organized channel through which grievances may be brought up and promptly considered. For instance, the workers of a given department may feel that the time clock is inaccurate or needs repairs, and the foreman may not take the prompt action which they think is needed. If the matter can be brought before a shop committee or works council, the time clock will without question be repaired immediately.

If the power of works councils is extended beyond mere routine consideration of rules and grievances, the council, together with the personnel department, may well handle matters of discharge. Rules relating to causes of discharge may be formulated by the works council and then administered by it. All cases in which, after conference between the foreman and the personnel department, discharge has been decided upon, can be brought before the works council for consideration upon request of the employee affected. Such procedure will do much to make the workers feel that they are indeed partners in the enterprise, but nevertheless this power should be granted the works council only after the cooperation of the foremen has been secured, or discipline will be likely to suffer.

When layoff is necessary, the works council can determine most satisfactorily just which workers should be affected. Some plants developed the idea of presenting to works councils such matters of basic policy as the production schedule, inasmuch as this directly affects the amount of work to be available. This procedure would certainly not be advisable until the works council had been in operation for a long time, and an experienced group of workers' representatives, who could appreciate the manufacturing and economic conditions involved, were members. Works councils may well consider routine matters relating to production, such as quality, salvage of scrap, safety, and general working conditions, when there are no grievances or special matters for attention at the meetings. To be effective, meetings must be regular, not called

at long intervals, and these subjects form a satisfactory fill-in for the discussions.

Types of works councils. The three main types of works councils which are utilized are the *industrial democracy* type, the *shop committee* type, and the *company union.* The industrial democracy type of works council attempts to apply to industrial organization a method of passing laws and settling policy similar to that used by the federal government. Ordinarily three bodies are provided as parts of the works council under this system. First, there is the House of Representatives, which is composed of representatives of the workers; then there is the Senate, which is composed of representatives of foremen and department heads; and finally there is the Cabinet, or representatives of the employer, usually major executives. Matters to be settled may be brought up first in either the House of Representatives or the Senate, in the form of a bill; after the bill has been passed by both houses, it goes for approval to the Cabinet, where it may be accepted or rejected. If rejected, it goes back to the house which originated it for revision or abandonment. A disadvantage of the industrial democracy type of representation is the lack of personal contact between representatives of management and the employees.

The shop-committee plan involves the selection of certain members of the works council by the employees and the selection of other members by the employer. These members usually sit together, and their decision is generally final. If they fail to reach a decision, the plan may provide for an appeal either to a major officer of the company or to a neutral arbitrator. This close personal relationship between management and employee representatives is a distinct advantage over the industrial democracy type of representation. Under this plan there may be one committee for the whole plant, or there may be departmental committees selected by the workers of given departments. Departmental committees consider minor matters, such as grievances, with representatives of the employer and select workers' representatives to sit on the works council, which is an appellate body for such minor matters and a body of original jurisdiction in the more important matters that are considered.

Operation of works councils. The exact organization, qualification of voters, term of office of representatives, number of meetings, and other routine matters will naturally vary with the necessities of the particular organization and with the desires of those forming the works council. There are, however, some general conditions which seem to be tried and applicable in almost all cases. Voters for employee representatives frequently have to be employed by the company for a certain specified period, usually about three months. The term of office of representatives

is usually a year, with elections held at different times, so that the entire committee is not overturned at once. Meetings are held at intervals varying from one week to a month.

Most plans call for an equal division of voting strength between the employees and the employer; an exception is the industrial democracy plans, where this same feature is provided for in another way. Frequently it is necessary to pass actions by more than a mere majority vote, sometimes by a two-thirds or three-quarters vote. This provision promotes permanence in the decision reached, but it also results in a certain number of cases not being settled by the works council and thus makes important the final authority. Regardless of the provisions for final authority in actions of the works council, it is necessary that the general management keep itself informed concerning what is going on and take an active interest in the proceedings. Otherwise the works council is bound to fail. As a matter of fact, no kind of collective relationship, regardless of the form it takes, can relieve management of its responsibility to provide constructive and inspiring leadership.

Some managers are afraid of any type of employee representation on the theory that they inevitably lead to outside unionization. This will undoubtedly be true if work relationships are unsatisfactory, but unsatisfactory work relationships always create a fertile field for unionization, works councils or no works councils.

Many managers have said that what the worker wants is not a partnership in the enterprise. What he wants is the certainty of steady work at fair wages, with an opportunity for advancement. If he is given this, these managers say that the worker makes no demands on them for representation or participation in management. If a manager is sure of this fact, and if he is conducting his business in a way that attempts to make things fair for both the worker and the employer, it is very probable that, as yet, it would be unwise to try the formation of a works council in that plant and far wiser to continue the broad-minded policy of management along the old lines which have proved successful and satisfactory to all concerned.

The future of works councils and company unions. The trend since 1935 has been away from the traditional works council, composed of representatives of both the management and employee groups, to the company union made up exclusively of a committee or committees of workers. The National Labor Relations Act and its administration have definitely contributed to this trend, although a few of the state labor relations acts have definitely outlawed the company union. Strong feelings exist among company union members. Mr. Henry L. Nunn of the Nunn-Bush Shoe Company, speaking before the Management Confer-

ence, State University of Iowa, March 31, 1939, stated in reference to their shop union, "Attempts of the C.I.O. and the A. F. of L. for affiliation have always failed. As one C.I.O. organizer said as he emerged from a meeting with the workers, 'It's not a union there; it's a religion.'" The same statement could be made regarding many of the so-called outside unions, or, as their members prefer to call them, "legitimate unions."

The Nunn-Bush employees have a union whose membership is confined to their own company.[4] The company's attitude toward unions is ably expressed as follows:

> We believe that Labor not only has the right to organize, but that Management will never succeed in getting the full cooperation of Labor unless it *is* organized. Labor has just as much right to state the terms on which it will work with Capital as Capital has to state its conditions.
>
> When the Nunn-Bush business reached that stage in its development where intermediaries between Management and Labor became necessary, we insisted on our workers organizing themselves. We adopted none of those questionable practices associated with Company Unions whereby Management seeks to control the Union. On the other hand, we had no intention of allowing the Union to dictate to us and therefore we adopted what we believe to be the only satisfactory safeguard—we deliberately surrendered our claim to dictate to our workers. This meant giving up many of the so-called "sacred prerogatives" of Management—the right of arbitrary discharge, the arbitrary settlement of hours, holidays, lay-offs, and rates of pay, and indeed everything which affects the workers' interests. Under our agreement with the Union all these questions became matters which could only be settled by joint agreement, failing which, arbitration.[5]

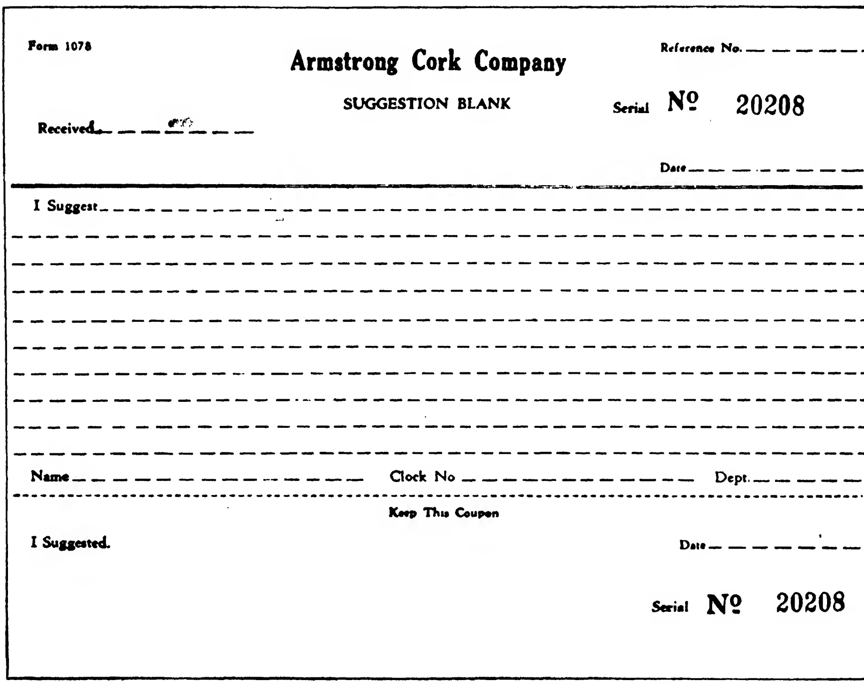
Although the old type of works council has largely disappeared, the independent company union is a virile organization for management-worker cooperation. There is even a tendency to form a federation of these independent company unions. The National Labor Relations Board will certify the independent company union as the lawful collective-bargaining agency. There is no reason, however, why an employer and his employees should not have the older type of employee works council if they desire it.

Suggestion systems. One of the oldest forms of cooperation between the employee and his employer is the suggestion system. It does not

[4] The Milwaukee plant has an intramural union which is not affiliated with an outside union, but the Edgerton plant has a C.I.O. union. The relations of the company to the C.I.O. union have been very pleasant.

[5] *Nunn-Bush Share the Production Plan,* The Nunn-Bush Shoe Company, 1946, p. 4.

possess the group appeal for collective action that the more formal systems of employer-employee cooperation have, but it does serve as a medium of communication for employees and management. For instance, it is common practice for employees to make a large number of suggestions concerning restrooms, rest periods, and general working conditions during the early days of a suggestion system. This type of suggestion



Form 1078

Armstrong Cork Company

SUGGESTION BLANK

Reference No.

Serial Nº 20208

Received

Date

I Suggest

Name Clock No Dept.

Keep This Coupon

I Suggested.

Date

Serial Nº 20208

FIG. 46.1. Suggestion blank of the Armstrong Cork Company.

decreases in proportion to other suggestions as time progresses, yet the means always remains for employees to suggest improvements in working conditions. Token rewards are usually made for suggestions that only improve working conditions. Suggestions that improve efficiency frequently are rewarded on some such basis as a percentage of the savings for a certain period, perhaps a year. One large company rewards not only the man making an accepted suggestion but also all his fellow employees who are working on the same job on which the improvement is made.

Figure 46.1 is a form used by the Armstrong Cork Company for use by their employees in making suggestions. Similar forms may be used with or without the employee's signature, or the signature may be op-

tional. Some employees may fear reprisals from their foreman or fellow employees when they make certain suggestions that reduce the amount of work needed for an operation or when they criticize working conditions. Under such circumstances the employee may tear off the numbered stub and file his suggestion, which can then be investigated on its merits. Accepted suggestions are published by numbers. The employee holding the stub for an accepted suggestion may present the stub and receive the award.

A suggestion system may be used with or without an organized employee-employer cooperative program. Careful follow-up by management is required, however, to make it a success.

Trade agreements. Trade agreements not only provide a minute description of basic wages, hours, working conditions, rules, and methods of discharge, but also frequently cover methods of performing operations. In the settlement of disputes these agreements usually prescribe some neutral arbitrator.

Trade agreements are negotiated through representatives of the union, who may or may not be actual workers in the plant or plants which the agreement affects, and officers of the plant or of the trade association which represents the employers affected. Disputes are ordinarily handled by departmental or plant boards on which both the union and the employer are represented. They may then be referred to a board for the industry as a whole or to a regional board, if more than one plant is involved. Finally, some method of arbitration may be provided.

The future of trade agreements. With experience in their operation, it may be confidently expected that trade agreements will become better administered in the future. Such improvement will include a broader view by the union of the necessities of industrial management and operation, particularly in securing economies of production, and a broader view by the employer of the aims of the union. Trade agreements, however, are applicable only to trades that are highly organized and to plants within those trades where the workers would rather deal through their union representatives than directly with employers through works councils or some other form of intracompany collective bargaining. In most industries the individual plant which maintains the confidence of its employees and, particularly, which provides wages and conditions of work equal to or better than the union standard, will probably continue to operate smoothly and in successful relationship with its employees without the use of trade agreements or even without the development of any form of works council or union. Such operation, however, can be based only on a broad, intelligently developed, basic personnel policy which has been formulated squarely on the idea of the development and

continuance of good will among the firm, the management, and the workers.

Employees' reactions to company policies. Regardless of the program inaugurated by a company, whether it involves price, quality of product, merchandising medium, personnel, or community, there ever remains the difficulty of determining just what the interested persons think of it. Management has long sought a method of determining just how the employees in general feel toward its policies. The works councils and other forms of employee-employer representation plans provide one means of exchanging ideas between management and men concerning many company activities. Another method of finding out what employees think about management is the use of questionnaires.

The Armstrong Cork Company of Lancaster, Pennsylvania, was one of the pioneers in the use of the questionnaire technique to determine how its employees liked the industrial-relations program.

The Thompson Products Company of Cleveland also has successfully used the questionnaire to obtain its employees' reactions to company policies. Questions that cover various company policies are given the employees to be answered. Questionnaires may be distributed by the foreman, representative of the personnel department, or some outside agent, such as a consultant or the representative of a university or college. The questions may be submitted to employees in groups to be filled out at once and to be collected, or they may be mailed by the employee to the company or outside agent. Usually the questionnaires are not signed. Generally the company publishes quite frankly the results of the survey of opinion. Such opinion surveys are by no means favorable in every detail to the company, but they afford a means of expressing employee approval or disapproval. Provision of this outlet usually promotes morale. The weak spots, as disclosed to management, provide a focal point for attempts to make improvements.

CHAPTER 47

INDUSTRIAL SAFETY

The status of safety in industry. Sixteen thousand workers were killed during 1945 in the course of their employment. During the same year 2,000,000 were injured to the extent of being compelled to lose time from work. The direct costs of these deaths and "lost-time accidents" were approximately $1,000,000,000; the indirect costs were approximately $1,300,000,000. These indirect costs arise from property damage and production slowdowns due to absence and lowered efficiency. The direct costs to society are made up of compensation insurance, including payments and overhead costs, uncompensated wage losses, and the cost of medical care. Absence from the job beyond the day of injury totaled 46,000,000 man days. An even greater loss was the loss in productivity of others near or associated with the injured person. These delays, together with the lost time when the damaged equipment was being repaired, totalled approximately 230,000,000 days.[1]

Management is keenly aware of the costs of accidents, as are the victims of the accidents. The great problem to be solved is to get the individual worker at the point of operations to realize his personal responsibility. "In fact it [securing such realization] means the safety education of literally everyone who manages, operates, supervises, designs, or works in any type of industry, manufacturing, trade, service, mining, farming, and transportation. Injury prevention must be interwoven throughout all work activities of the nation." [2]

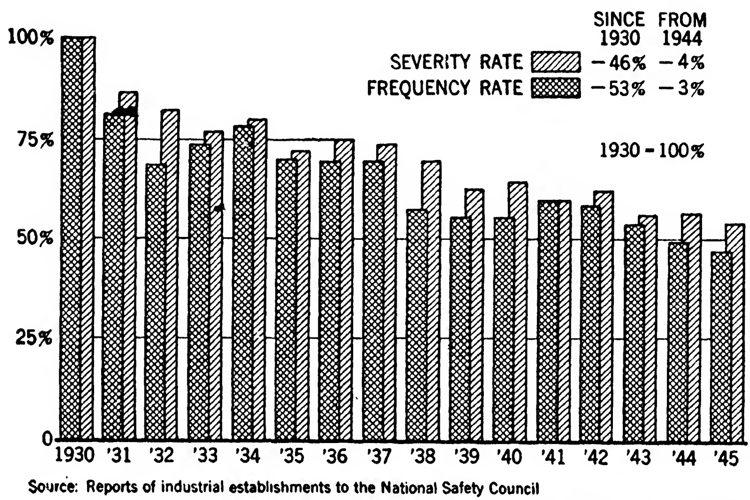
The accident-prevention movement. Enlightened employers became keenly aware that many accidents were unnecessary and costly about the turn of the twentieth century. The passage of various state workmen's compensation laws (1910–1925) gave impetus to the activities of a few employers. The National Safety Council, Inc., was organized in 1913 and has enjoyed a long and successful career, holding a position of unquestioned leadership in the safety movement. It is financed by the

[1] See National Safety Council, Inc., *Accident Facts,* 1946 Edition, p. 20. The source of much of the material in this chapter is the National Safety Council, Inc.

[2] R. P. Blake, Senior Safety Engineer, Department of Labor, Division of Standards, Washington, in a letter to the author. Mr. Blake provided many constructive suggestions and ideas used in this chapter.

member companies. The National Safety Council, Inc., collects statistical data regarding the causes of accidents and conducts a vigorous campaign for safe practices. Its publications have been very helpful in promoting the safety movement.

Most of the full-time safety men are members of the American Society of Safety Engineers, an affiliate of the National Safety Council, Inc. The American Society of Safety Engineers is an organization that is



Courtesy, "National Safety Council Accident Facts," 1946 Edition

FIG. 47.1. Chart showing the decline in frequency and severity rates.

striving to raise the standards of its members to a truly professional level. This is a wholesome movement that will undoubtedly exert a profound influence upon the reduction of accidents.

The American Standards Association, formerly the American Engineering Standards Committee, serves as a clearing house for standards. It has become a federation of technical and professional societies, trade associations, and some government agencies.

The nation as a whole and managers in particular have been aroused to the economic and humanitarian aspects of the safety movement. It is to be hoped that the union movement will become as effective at the work level as its leaders have been in their conventions and public statements. If this situation should be realized, the downward movement in accidents will become even more pronounced. Figure 47.1 shows the reduction in both severity and frequency rates [8] from 1930 to 1945 for

[8] The frequency rate is the number of disabling injuries per 1,000,000 man hours worked. The severity rate is the number of days lost per 1000 man hours worked.

industry as a whole. Figure 47.2 indicates the remarkable reduction in accidents for the members of the Portland Cement Association.

Does safety work pay? The fact that as many as 10,000 persons have attended a single annual conference of the National Safety Council indicates the interest of industrialists in safety. Business men would not

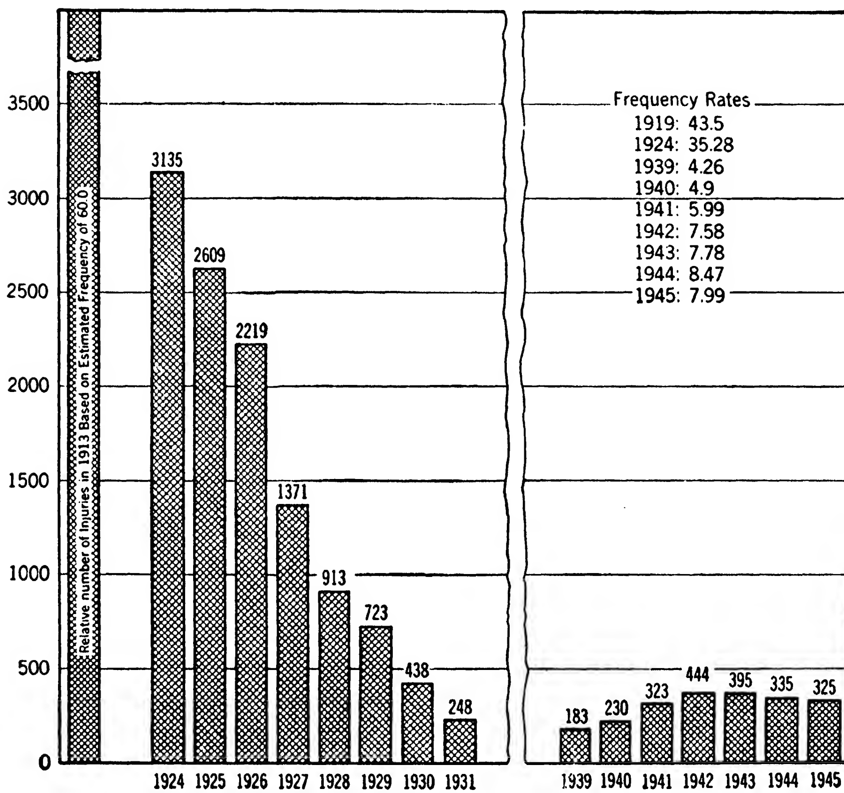


FIG. 47.2. Number of injuries to members of Portland Cement Association.

send representatives in such numbers to safety conferences unless the interest could be translated into economic as well as humanitarian terms. Practically every large company in the United States has a formally organized safety program. All of them have a vital economic and social interest in safety, even though a few may carry on their work through the regular line organization. A bad accident rate may run into a substantial per capita cost. To reduce this rate is to reduce costs. The costs of injuries average at least five times the sum of compensation paid plus the medical expenses. For instance, if compensation paid was $200

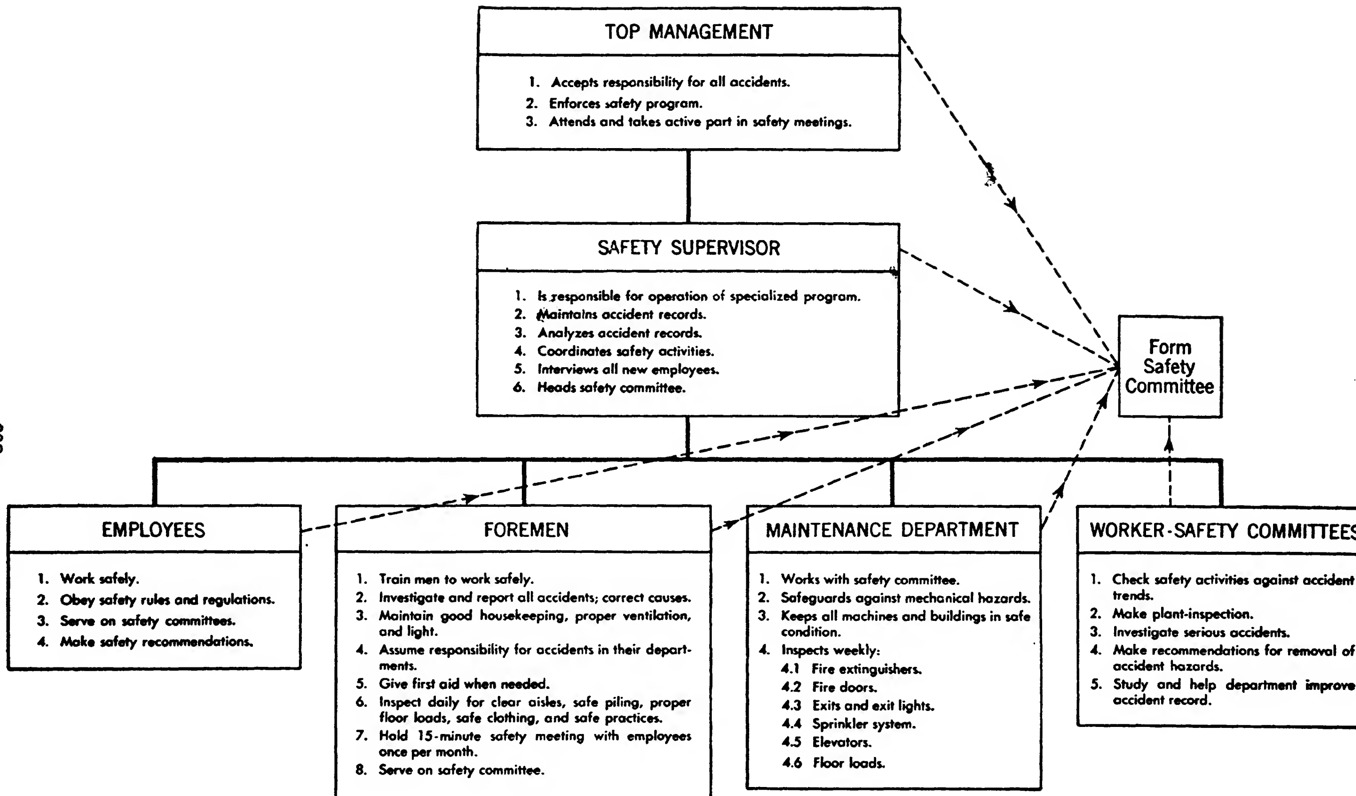
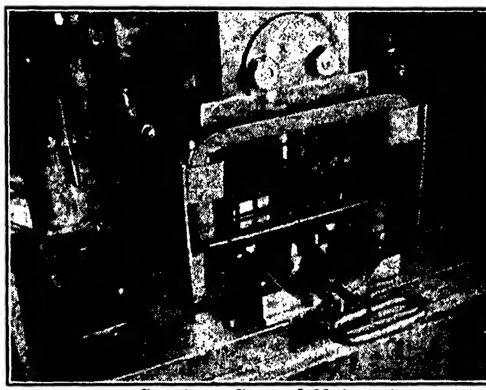


Fig. 47.3. Chart showing the safety functions of various groups in the plant. To this should be added the engineer responsible for safety in machine design and the methods for process safety.

and medical expense for the same accident was $100, the total cost to the employer, when figuring every factor, would be approximately $1500.[4]

Organizing to prevent injuries. The rigid observance of safety practices is not a one-man job. It requires the cooperative effort of every person associated with the operations. From a management standpoint the attitude of top management and the foreman is most important. The big problem is to keep top-management's sound approach constantly before the foremen. Safety is primarily a line responsibility. The staff



Courtesy, General Motors Corporation

FIG. 47.4. Basket guard for punch press, Ternstedt Manufacturing Company, Detroit. (See handle for feeding parts into press.)

service rendered by the safety engineer or supervisor is merely an aid to the foreman and an advisory service to top management. As a staff function the safety department may readily be attached to the personnel department that specializes in the personnel aspects of the organization without being responsible for operations (see Fig. 6.5). Figure 47.3 illustrates the various functions that are performed by the several interested parties.

Guards. Unless mechanical hazards are guarded adequately, no plant can expect to win the workers' cooperation in educational programs for accident reduction. The necessity of adequate illumination as a safety factor was discussed in Chapter 15. Other types of physical dangers include those arising from power-transmission equipment, points of operation on machinery, slippery floor and stairway surfaces, and danger to the eyes from flying particles.

Point-of-operation guarding is coming to be of great importance, because, although power-transmission machinery is usually well guarded,

[4] See R. F. Blake, *Industrial Safety,* Prentice-Hall, 1943, pp. 22–29.

Courtesy, Bendix Products Division, Bendix Aviation Corporation

FIG. 47.5. The guard pulls the man's hands from under the descending tool if he forgets to do so.

Courtesy, Junkin Safety Appliance Company

FIG. 47.6. Guard that forces the operator's hands away from the descending tool if she does not remove them herself. Note the safety cap, which prevents the girl's hair from becoming entangled in moving parts.

Courtesy, National Safety Council

FIG. 47.7. Safe practice in grinding, Lane Technical High School, Chicago.

little has been done with points of operation, except the first two of the following three classes: (1) accidents from flying particles—emery and other abrasive wheels; (2) accidents due to contact with the moving parts of machines, as on punch presses; (3) accidents due to kick-backs of work, or parts of the machinery which move flying through the air. Examples of the third class are lumber kicking back from a circular saw

and shuttles flying from the loom. Figure 47.4 illustrates an effective point-of-operation punch-press guard. Other types of guards (Fig. 47.5) pull the worker's hands away from the descending tool. Figure 47.6 portrays another type of guard for a punch press. Figure 47.7 shows a properly guarded grinder with an individual motor drive, thus eliminating the necessity of guarding the belt and pulley. It will be noticed that goggles are worn even though the grinding wheel is well guarded.

Accident prevention by making floors and walk-ways safe is a big factor in reducing the industrial-accident toll. A study by the National Electric Light Association indicates that more than one third of all falls occur on the level and on stairways, not from poles, scaffolds, or other equipment.

Adequate protection will save a large percentage of the eyes lost in industry each year. There is great need for having goggles handled by someone familiar with their use. This person should appreciate what constitutes a fitted goggle, so that the wearer may, in addition to obtaining protection from the eye hazard he is compelled to encounter, be given the assurance of a feeling of security behind the devices.

Proper clothing for the worker is almost as important as the guarding of machines. The dress of an individual influences his attitude. Safety garments tend to induce a safety attitude. Figure 47.8 illustrates appropriate dress for a woman working on machines.

Occupational diseases.[5] Occupational diseases in industry are relatively unimportant in comparison to accidents, being from 4 to 5 per cent of the total of health and accidental injuries. Nevertheless occupational health injuries constitute a very real drag upon the individual, society, and business. The field of occupational diseases has not been explored as intensively as accidents. It is not always possible to trace a given disease to the occupation unless poisoning, such as lead poisoning, is involved. The most common occupational diseases or ailments are dermatitis, abrasions, bursitis, synovitis, benzol poisoning, lead poisoning, and difficulties arising from silica and dust. Each area and industry has its peculiar problem in relation to occupational diseases.

Each industrial enterprise should study its experience and concentrate on eliminating the causes of its occupational diseases. Close cooperation among the medical service, operating department, and engineering and process division is required to get effective results. Society is becoming keenly aware of the broader implications of occupational diseases. There are individual differences in the workers' reactions to occupational dis-

[5] See National Safety Council, Inc., *Accident Facts,* 1939 Edition, pp. 12 and 22, for data supporting the statements made in this paragraph.

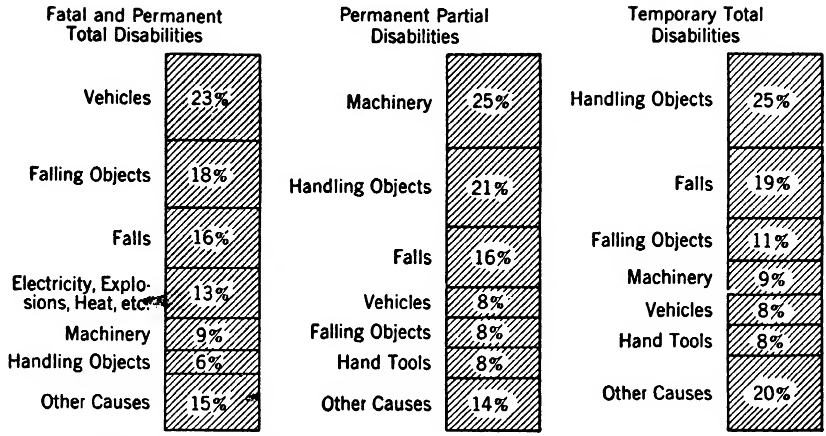
eases, just as there are individual differences in reacting to the pollen of ragweed. A careful check-up by the medical department may readily detect many individuals not suited to particular occupations. An equit-

Courtesy, the Travelers Insurance Company

Fig. 47.8. A woman appropriately dressed for safe work.

able transfer or other adjustment in such cases will tend to reduce occupational diseases.

Using facts to promote safety. Figure 47.1 shows the decline in both frequency and severity rates of accidents since 1930. Frequency has declined more than severity, but both have made a remarkable showing. Data are available by industries from which trends for each industry may be established and the individual manager may measure his own performance against that of his industry as a whole. The chart given



Source: Eleven State Labor Departments

Courtesy, "National Safety Council Accident Facts," 1946 Edition

FIG. 47.9. Injuries by sources.

TABLE 47.1

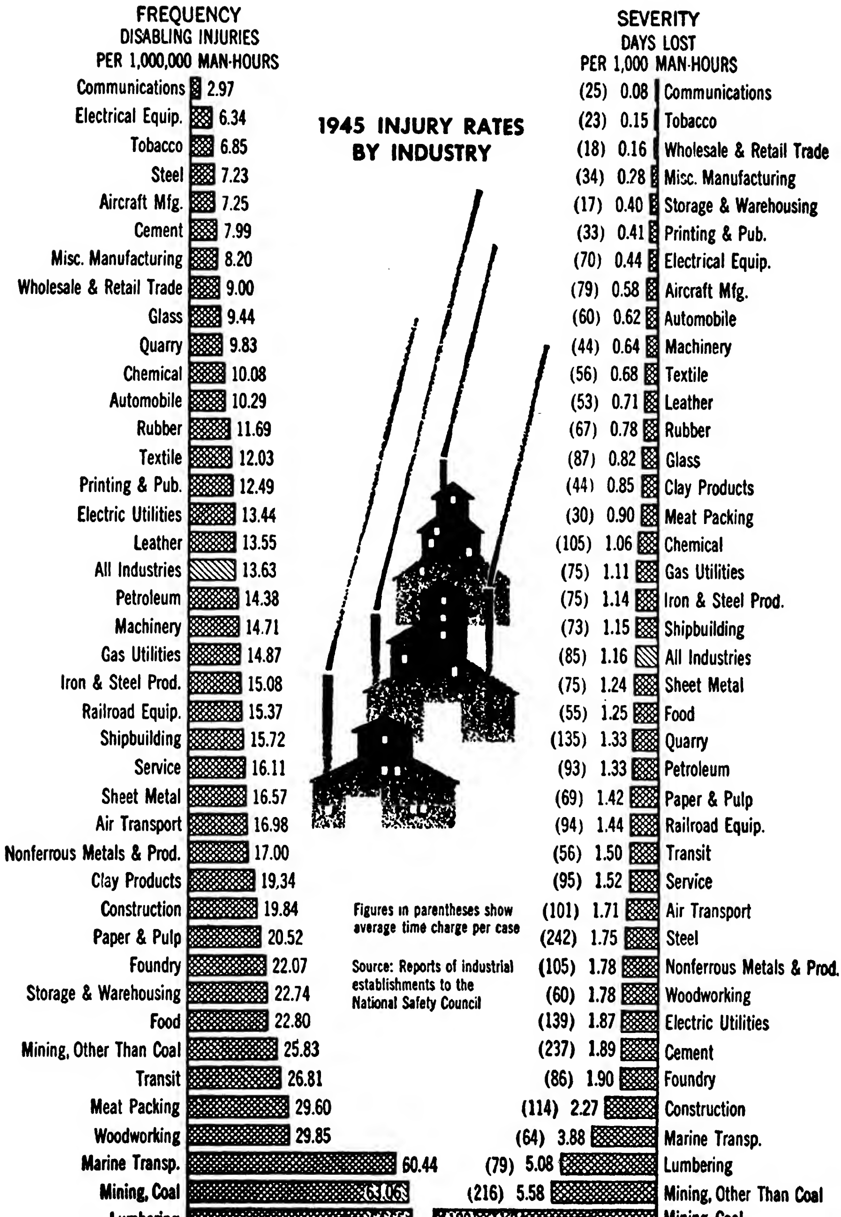
CAUSES (BY PERCENTAGES) OF ACCIDENTS *

Unsafe Acts	
Unnecessary exposure to danger	26
Improper use of or unsafe tools	16
Non-use of safety devices	15
Unsafe loading or arrangement	10
Operating at unsafe speed	7
Working on moving equipment	6
Improper starting or stopping	5
Other unsafe acts	2
No unsafe act	13
	100%

Personal Causes	
Lack of knowledge or skill	48
Improper attitude	31
Bodily defects	3
No personal cause	18
	100%

Mechanical Causes	
Hazardous arrangement	34
Defective agencies	18
Unsafe apparel	15
Improper guarding	9
Improper light or ventilation	2
No mechanical cause	22
	100%

* Source: National Safety Council, *Accident Facts*, 1939 Edition, p. 19.

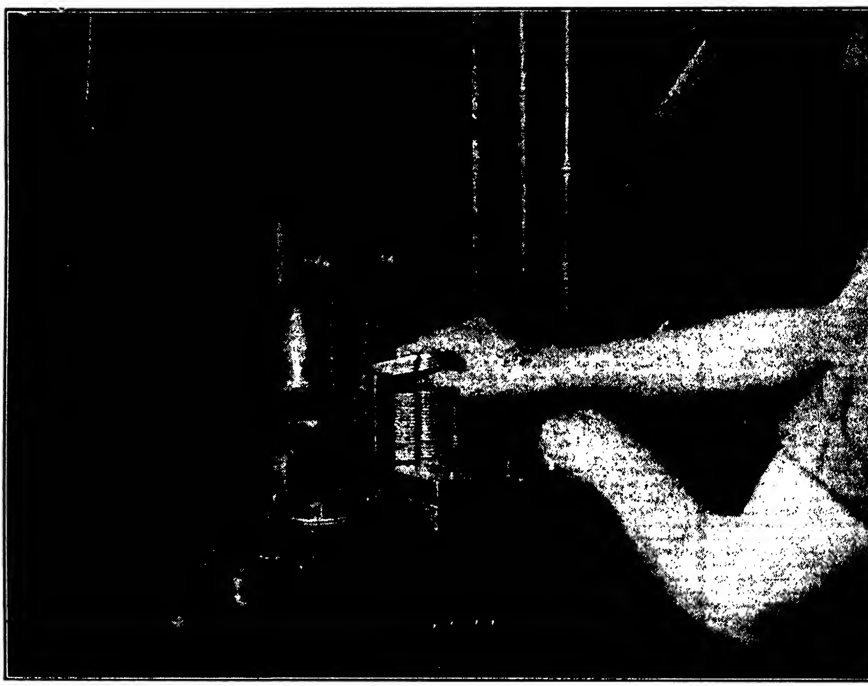


Courtesy, "National Safety Council Accident Facts," 1946 Edition

Fig. 47.10. Injury rates by industries.

on p. 615 shows the frequency and severity rates for various industries for 1945.

Figure 47.9 shows the distribution of compensated industrial accidents. This same information is available by industries (Fig. 47.10) and may well serve as a challenge to an individual enterprise. It also points to places where effective work can be done. The National Safety Council



Courtesy, National Safety Council

FIG. 47.11. A fixture constructed for both safety and production.

reports that about 87 per cent of all work accidents involve some unsafe act, and that 78 per cent have some mechanical or material cause. In approximately 80 per cent of the unsafe acts some definite personal cause was responsible. Mechanical causes accounted for about 20 per cent of the total accidents. The breakdown of the *unsafe acts, personal causes,* and *mechanical causes* in Table 47.1 indicates definitely the responsibility of management for proper selection, training, and discipline of employees, as well as to management's responsibility for removing most of the mechanical causes.

Frequently guards are not used by the workmen because they slow down their production. Piece workers do not like to have their produc-

tion slowed down even though the rate is supposed to compensate for the safe practice. Some of the safety devices have been inadequately engineered and have placed an unnecessary burden on production. On the other hand, careful engineering may change a hazardous operation to a safe one and increase production at the same time. Figure 47.11 shows a

Courtesy, the Travelers Insurance Company

Fig. 47.12. This picture was run as a "photo quiz." How many hazards can you count?

device that is carefully constructed for both safety and production. The safety engineer should not sacrifice the workers' physical safety for increased production. On the other hand, he should consider production requirements and harmonize the two. The installation of an automatic feed, using strip stock, not only raises the safety factor of a punch-press operation but also increases production. The motion- and time-study department should be a strong ally of the safety department. Their long-run interests are identical in many respects.

Educating the workman in safe practices. Departmental or group safety committees should be organized, and the competitive spirit between departments aroused. An active safety committee will work strenuously to have a better record than its neighbor, and, once aroused, the men learn how to put the doctrine across. Vigorous and pointed safety bulle-

tins should be abundantly posted and *frequently changed.* Plant cartoonists will find this field an admirable one in which to work, and the fact that cartoons and bulletins are homemade and cite home events will increase their effectiveness.

Worker education in safe practices should be wisely planned and effectively executed. It never ceases; constant follow-up is required. One of the most frequently overlooked persons is the old timer who has been around the shop for years and "should know." When he is transferred to a new job, he should be carefully checked regarding the safety factors. Otherwise he is likely to assume that he knows what to do and unwittingly violate some sound practice, thereby hurting himself. Older workers' records are good in terms of safety. "Old timer," in the sense used here, refers to work experience, not age. Such a person may be 30 or 60 years old, but he should be given safety training whenever his job is changed.

The plant magazine forms an excellent means of promoting safety among the workers (see Fig. 47.12). Nearly all plants which have safety programs of any size utilize safety posters of some kind. The National Safety Council has an elaborate poster service, and most of the casualty insurance companies include a poster service as one of the items in their workmen's compensation policies.

One of the direct results of safety education is to reduce the number of infection cases from accidents by having the injured worker report promptly to the dispensary for treatment (see Fig. 42.1, p. 555). A sympathetic doctor and nurse will work wonders in persuading men to come to the hospital for first aid, and first aid prevents infection. Persuasion, as well as regulations, should be used for this purpose.

APPENDIX A

EXPLANATION OF GENERAL MOTORS ORGANIZATION CHART

GENERAL MOTORS CORPORATION

Subject: General Motors Organization, organization chart revised to July 1, 1946 — *No.:* 799

To: General Managers of Divisions
General Operating Officers
Group Executives
Staff Executives
Heads of Staff Sections — *Date:* July 3, 1946

The enclosed organization chart of General Motors Corporation has been revised as of July 1, 1946. It reflects all personnel and organization changes made at the meeting of the Board of Directors on June 3, 1946, and July 1, 1946, as well as any changes which have occurred since the previous chart was issued on January 8, 1946. (See Fig. 6.6.)

The major changes from the previous chart are as follows:

1. The former Policy Committee, which dealt with both operating and financial policies, has been divided into two committees, as follows:
   a. *Operations Policy Committee.* The Operations Policy Committee, during intervals between meetings of the Board of Directors, shall have and may exercise the powers of the Board of Directors except the powers assigned to the Financial Policy Committee, the Audit Committee, and the Bonus and Salary Committee, in the management of the business and affairs of the Corporation.
   b. *Financial Policy Committee.* The Financial Policy Committee, during intervals between meetings of the Board of Directors, shall have and may exercise the powers of the Board of Directors except the powers assigned to the Audit Committee and the Bonus and Salary Committee, in determining the financial policies of the Corporation and in the management of the financial affairs of the Corporation, including all accounting policies and procedures.
2. The Administration Committee is charged with the responsibility for making recommendations to the Operations Policy Committee with respect to the manufacturing and selling activities of the Corporation, and will also make

recommendations on any other matters affecting the business and affairs of the Corporation which may be referred to it by the Board of Directors or the Operations Policy Committee.

3. The Policy Executive Group has been discontinued.
4. The former Policy and Product Groups of the Administration Committee are now Policy Groups of the Operations Policy and Administration Committees, divided as follows:
   a. *Policy Groups of Operations Policy Committee*

      Aviation
      Canadian
      General Engine
      Household Appliance
      Public Relations
      Overseas

   b. *Policy Groups of Administration Committee*

      Distribution
      Employee Cooperation
      Engineering
      Manufacturing
      Personnel

5. The Legal and Financial Staffs, as well as the Finance and Insurance Group of Subsidiaries and the Associated Companies Group, are under the jurisdiction of the Financial Policy Committee and report to that Committee through the Chairman of the Financial Policy Committee.
6. The Corporation's operating divisions have been regrouped as follows:

   Car and Truck Group
   Body Group
   Accessory Group
   Buick-Oldsmobile-Pontiac Assembly, Dayton, and Household-Appliance Group
   Engine Group
   Overseas and Canadian Group

A chart showing the membership of the various Policy Groups, together with a calendar showing the scheduled meeting dates of the Board of Directors, the governing committees, and the Policy Groups, are attached for your information.

Additional copies of the organization chart suitable for framing, as well as extra copies of the membership chart and the calendar, may be secured from the Budget and Procedure Section, Detroit, Michigan.

C. E. Wilson (*signed*)
President

APPENDIX B

DETAILS OF STANDARD NOMENCLATURE

The requirements of daily operating conditions demand the application of a standard nomenclature to the items that have been arranged through the development of a classification. Something more accurate, more concise, and less ambiguous than names or words is necessary. Such requirements are met through the use of symbols.

Symbolization. Symbolization is the assignment to all classified items of a series of related characters, in such a manner as to aid in the recognition of the item and definitely to fix its identity separately from all other items in all phases of the business. The completed set of symbols comprises a system of standard nomenclature for a business.

A number of effective methods have been devised for the development of standard nomenclature, some of which are in common use. As the base of the symbol system one of the two main methods utilizes numbers; the other, letters. Each method frequently uses the main device of the other to aid in the expression of particular conditions. Methods utilizing numbers may be again divided into straight numerical systems and Dewey Decimal Systems which express relationships by the positions of numerals to the left or right of the decimal point. Both are developed along essentially the same lines. Methods that are based primarily on the use of letters are ordinarily called mnemonic, because they are designed with the primary idea of having the symbol easily remembered.

Compromise is the basis of the art of working out standard nomenclature. Deviations from a strictly logical series of symbols are often necessary to preserve a logical classification, which is more important. Effective symbols should be as short as possible, should be absolutely definite, so that one symbol can mean one and only one thing, and should be as mnemonic as possible.

Numerical symbols. The numerical system of symbols is used in a large number of businesses. With this system the symbol may consist of one or more separate numbers. For instance, expense items are frequently designated by indicating the number of the unit of the business incurring the expense, followed by the symbol representing the expense. Whenever this system is utilized, a block of consecutive numbers is usually assigned to each general class into which the activities of the business are divided. The advantages of the numerical system are:

1. Its seeming simplicity at first glance.
2. Its ready adaptability to use in connection with tabulating machines.
3. Its particular simplicity when only accounts are classified.

This last factor is the cause of the almost universal adoption of the numerical system when only accounts are classified. The disadvantages of the numerical system, compared to the use of letters (usually termed the mnemonic system), when combined into a system alleged to be memory-aiding, are the following:

1. It is difficult to associate the symbol with the item classified, which is a particular disadvantage in items of stores, product, etc.
2. Only 10 class divisions are possible, as the system is generally used, whereas there may be 22 if letters are used.
3. Because of the use of numbers for all purposes, sizes cannot be readily shown in the symbol.
4. In stores or production-control work, the symbols tend to become extremely lengthy.
5. It is difficult, if not impossible, to develop a series of symbols to cover all the items in the business without repetitive numbers. These disadvantages are somewhat modified in the manufacture of a standard product, where the number of items to be classified is somewhat less.

The Dewey Decimal System, although essentially the same as a numerical system, is not so well adapted to business as to library work, because of the likelihood of misplacing the decimal point.

The following is an extract from an example of the development of a numerical nomenclature:

Department Numbers (1–199)

Executive Department (1–9)

1. President's Office
2. Vice-President's Office
3. Treasurer's Office
4. Secretary's Office

Comptroller's Division (10–19)

11. Credit Department
12. Accounts Payable Section

Sales Division (20–29)

21. Domestic Sales Department
22. Export Sales Department
23. Sales Promotion Department

General Office (40–49)

41. Stenographic Section
42. Mail Section

Maintenance Department (70–79)

71. Machinery Section
72. Equipment Section

Production-Control Department (100–109)

101. Planning Department
102. Standards and Methods Department

Asset Accounts (200–299)

Plant (200–224)

201. Land
202. Buildings

Equipment (225–234)

226. Machines
227. Motors

Current Assets (260–271)

261. Cash-General Funds
262. Cash-Cashier's Fund

Investments (272–279)

273. Sinking Funds
274. Contingent Funds

Liability Accounts (300–399)

Funded Debt (300–309)

301. Bonds
302. Coupon Notes Payable
332. Capital Stock Premium (Subscribed)

Capital Stock (350–359)

351. Capital Stock, Common
352. Capital Stock, Preferred

Revenue Accounts (400–499)

401. Profit and Loss
402. Manufacturing
403. Sales

Expenses (500–)

501. Salaries—Executives
502. Salaries—Clerical
503. Commissions
504. Retainers—Premiums, Bonuses
511. Traveling
512. Entertaining
513. Miscellaneous Labor Cost
514. Janitor Service

In the utilization of this classification, departmental expense symbols are formed in the way that the following examples indicate:

23502—Sales-Promotion Department Clerical, Salaries
23511—Sales-Promotion Department Traveling, Expenses
101504—Production-Control Department, Bonuses
102501—Salary, Head of Standards and Methods Department

Numerical symbolization of material is extremely common and is especially valuable in the manufacture of a few standard products for which standard materials are utilized. In such cases, effective numerical stores symbols can be built up. Although nothing in the symbol itself recalls the article referred to, constant association of the symbol and the article soon makes possible the prompt association of the article and the symbol name by those who daily utilize the symbols. An example of a stores classification, numerically symbolized, is not given, since it merely involves the numbering of the articles of stores and product in sequence, after they have been classified.

In plants manufacturing diverse products it is extremely difficult to build up a simple and effective series of numerical symbols for stores. Symbols soon become involved; and, since they do not readily recall the article they describe, and, furthermore, usually duplicate other numerical symbols used in other phases of the business, some form of mnemonic symbol is usually adopted. As an example of the manner in which numerical stores symbols become readily involved, the following symbol used by a paper-manufacturing plant is given: 801–2–3–0–5–16. This symbol was used to designate coupon bond paper, loft dried, second quality, glazed finish, weighing 16 pounds to a folio.

Machines are ordinarily classified by an arbitrary assignment of numbers to classes of machines and individual units within the class. The first two numbers usually indicate the class of machine and the last the machine number within the class, as shown by this example:

0501—Automatic-Feed Turret Lathe, 1
0502—Automatic-Feed Turret Lathe, 2
2902—Gear Cutter, 2
3601—Plain Vertical Milling Machine, 1

Some plants put the number of the department in which the machine is located as the first digit in the number of the machine. This practice is inadvisable, since, when machines are moved from one department to another, the symbols not only cease to have any meaning, but are confusing.

Mnemonic nomenclature. One of the best types of nomenclature yet devised, which meets all requirements in practically every case and is of great practical value, is the system based on the use of letters with the aid of numbers, commonly called the Mnemonic System. This system was worked out by Frederick W. Taylor and his associates, and their pioneer work in nomenclature stands as the best single contribution to nomenclature work in American industry. One of the most valuable factors of this type of nomenclature is that a system can be devised to classify and symbolize every single phase and item of a business in a way that makes the nomenclature a unified whole without repetition of symbols. In any business, however, only those items for which standard nomenclature is required need be classified and symbolized.

This Mnemonic System is based on a complete and exhaustive analysis of every detail of labor, materials, and organization involved in a business. All the elements are divided into logical groups, first into broad general divisions and then into subdivisions, groups, sections, subsections, and so on, each designated by a letter. Where possible, the letter chosen is the initial letter of the name of the item or some significant letter in the name. Numbers are used to designate dimensions, job numbers, or lot numbers, depending on their place in the symbol. Numbers are also used to designate different items within a class. If there were eight or nine kinds of plain office pencils in a storeroom, numbers would be used to designate the various kinds instead of going to the detail of adding a letter for each variety. With this last condition as an exception, letters and numbers are thus, wherever possible, suggestive of that which they represent.

Since one classification and system of nomenclature is to be provided for all items of the business, a base sheet can be drawn up indicating the first letter, or main classification, of each phase or item of the business. Such a base sheet is shown as Fig. B.1. This base sheet indicates that the various activities of the organization have been grouped under three main heads: B, Business Division (including Personnel); C, Selling Division; and D, Manufacturing Division. If some other phase of the business is made a main division, it, too, should be given, on this base sheet, a primary letter to designate it, as E, Engineering Division. A is reserved for the general accounts of the business, X is reserved for all tools, Y for all machinery, and Z for all buildings. These last three letters may represent either the physical item or the account covering this item. No confusion can exist here because of the absolutely different usage involved. The letters from F to W, inclusive, are reserved for products with the exception of S, which is reserved for stores or raw material. Semifinished material is represented by subdivisions of the product symbols, F to W. This reservation of letters applies only to the first

ITEM CLASSIFIED	DATA FOR CHARGING OF EXPENSES
A—GENERAL ACCOUNTS B—BUSINESS DIVISION C—SELLING DIVISION D—MANUFACTURING DIVISION E—ENGINEERING DIVISION *	General Expense ← Selling Expense ← Shop Expense ← Engineering Expense ← —< If both questions are answered NO then the charge must be against DEPARTMENTS
F, G, H, J, K, L, M, N, P, R } PRODUCTS	1ST QUESTION ←—— Begin Reading Is the expenditure one involving work on product to be sold? NO——→ ←——YES Worked Materials or Product which will ultimately be sold to Customers
S—STORES	
T, V, W } PRODUCTS	
X—FIXTURES, TOOLS Y—MACHINERY, MOTIVE POWER Z—BUILDINGS	+ 0 ← 2ND QUESTION Does the expenditure increase the permanent value of the Plant? < YES)————(NO →

* If main division; otherwise under manufacturing.

\+ Partly charged to asset accounts and partly to shop expenses.

0 Construction or addition to equipment which wholly increases permanent value of assets.

Fig. B.1. Base sheet for mnemonic classification.

letter of a symbol. The letters I, O, Q, and U are never utilized in mnemonic classification, since the first three are likely to be confused with numerals, and the last with V.

General accounts, represented in the main classification by symbols beginning with A, may be symbolized as illustrated by the following example:

A—General Accounts

AA	Revenue Accounts	AM	Material Accounts
AB		AN	Unfunded Debts
AC	Current Assets	AP	Plant Accounts

After these main subdivisions of accounts have been made, actual accounts may by symbolized by further subdividing these divisions mnemonically or by merely adding account numbers after the two-letter symbol. Inasmuch as mnemonic symbols are utilized less to designate accounts than for any other purpose, no further examples will be given.

Organization nomenclature. The following method of building up mnemonic symbols may be used in designating the various portions of the organization which have been classified. The nomenclature thus developed indicates immediately the relation of each unit of the organization to the organization as a whole. It is useful from that standpoint in the day-by-day operations of the business, as well as for expense division and distribution.

B—Business Division

BF	Office Manager	BT	Cost-Accounting Section
BG		BV	Miscellaneous Business
BH	Cashier	BW	

Office Manager's Group

BFA		BFM	Mailing Unit
BFB		BFN	Messenger Service

D—Manufacturing Division

DA	Auxiliary Departments	DM	Milling Department
DB	Blacksmith Shop	DN	Foundry
DC		DP	Punch-Press Department

Expense nomenclature. Expenses incurred may be designated by the use of one of the following symbols, placed after the symbol of the department, division, or shop responsible for the expense. If there is fear of confusing the expense symbol with a designation for the subdivision of a department, zeros may be inserted, and the expense symbol will thus always appear in the fourth or other predetermined position. Example: BFOA—Salaries, Office Manager's Office.

A	Salaries, Commissions and Wages	M	Machinery Repairs and Maintenance
B		N	Retainer—(Premiums, Bonuses)
C	Consulting (including Legal)	P	Power Transmission

If further subdivision of these expense charges is desirable, it can be best accomplished by numerical subdivision before the letter designating the expense, as:

1A	Salaries, executives	5A	Janitor Service
2A	Salaries, clerical	6A	Material-Handling Labor Cost
3A	Commissions	7A	Crane-Operator Labor Cost, etc.
4A	Miscellaneous Labor Cost		

Thus clerical salaries for the planning department will be segregated under the symbol DAP2A, and janitor service for the whole shop will be DOO5A.

Product and worked-material nomenclature. The nomenclature of product and worked materials under this scheme is provided for by symbols beginning with the letters F to W inclusive, with the exception of S. Thus in a plant manufacturing miscellaneous types of locks the product classification might be as follows:

F		N	Night Latches
G		P	Padlocks
H		R	

When a plant manufactures one composite product, such as an automobile, it is desirable to treat it as two or more distinct things, such as chassis and body. The important point about setting up a workable product classification is to visualize every group which goes into the final assembly. These groups are then broken up into divisions, sections, and subsections.

To illustrate the methods of classifying and symbolizing these groups and sections it is advisable to follow through the construction of nomenclature for one of the products enumerated above If we select padlocks, it is first ascertained that there are various kinds of padlocks, as follows:

PD		PR	Railroad-Switch Padlocks
PE		PS	Steel Padlocks (Except PH)
PF		PT	
PG		PV	
PH	Heavy-Duty Padlocks	PW	

The final product symbol is thus seen to be actually represented by two letters rather than one.

If we select heavy-duty padlocks, it is found that they are manufactured by assembling, in final assembly, several subassemblies, as follows (see Fig. B.2):

PHB	Back Assembly	PHM	Miscellaneous Assembly (Separate parts going into final assembly)
PHD	Dog Assembly		
PHL	Bolt Assembly	PHT	Tumbler Assembly

The back group or assembly is composed of a number of parts, which, for convenience, may best be expressed as numerals, placed before the last letter. If the product were more complicated and were composed of a number of subassembly

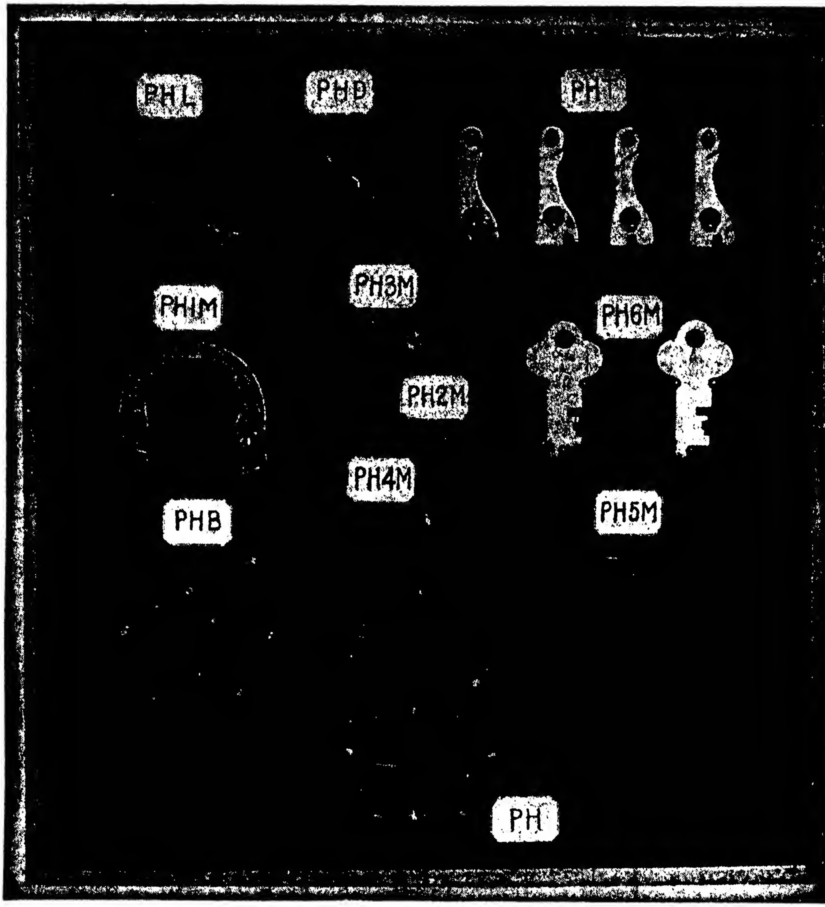


FIG. B.2. A 2½-in. heavy-duty padlock. Finished lock (*front cut open*), subassemblies, and components entering into final assemblies. (The symbols used are not those of the Miller Lock Company, manufacturers of the lock.)

sections, which were in turn assembled into the main subassembly, four or five letters might be used to symbolize all these items. In such a case the component of the last subassembly would again be designated by numerals placed before the last letter. The back group may be designated as follows:

PH1B	Back	PH4B	Shackle Post
PH2B	Case Stud	PH5B	Dog Stud
PH3B	Bolt-Spring Post	PH6B	Shackle-Spring Post

Unless the purpose of developing such elaborate symbols is briefly considered at this point, it may seem that they are unnecessarily complex. Each part which goes into the final product must be made, usually by performing several opera-

tions. It must be routed through the plant and assembled with other parts to become a portion of the final product or the whole of it. As such it must be controlled, and to be controlled it must be designated in some manner, either by a name or by a symbol. Furthermore, all parts must be stored at times and yet be readily available when wanted. Some designation must be attached to each part, in order that it may be stored properly and so designated that it will be readily available or can be eparately accounted for. The system of symbols being described, in addition to fulfilling all these requirements, readily shows the relationship of one part to another.

The worked-material symbols can be arranged to show dimensions or size of the product, so that the different varieties of similar products may be distinguished. Thus, if the product is a 2½-inch heavy-duty padlock, the symbol becomes P 2½ H. This size designation will be carried by every part going into the lock, as P 2½ H1B, back for 2½-inch heavy-duty padlock.

The worked-materials classification serves as a means of designating shop operations. This is accomplished by inserting the number of the operation, in the sequence which makes the piece, in front of the piece symbol. Thus 1P 2½ H1B is the first operation in the manufacture of the back for the lock. The second operation in the final assembly is 2P 2½ H.

The worked-materials symbol may be utilized also to show the lot number of any order in process. This may be accomplished by the addition of the lot number at the end of the product or worked-material symbol. Thus P 2½ H7 represents lot number 7 of 2½-inch heavy-duty padlocks.

From the foregoing it becomes apparent that there are certain rules of number utilization in mnemonic symbols which have been built up on the basis of long and hard experience, as follows:

1. Only operation symbols may be used as prefixes to worked-material symbols.
2. Care must be utilized in the insertion of dimension numbers before the last two places of a worked-material symbol lest these be confused with the part symbol.
3. Numerical parts of the worked-material symbol may not be placed after the last letter, as this place is reserved for lot numbers.

Stores or raw-material nomenclature. It is in the classification of stores or *purchased materials* that the greatest possibility for variations in the methods of classifying is found. Because articles are bought from several manufacturers under different names, although the articles may be the same or similar, an additional difficulty is faced. Because of the choice of methods, and the possibility of ambiguities in the classification, it becomes essential that every detail be carefully guarded. Those articles of stores which are special, rather than standard, are not classified, but are given serial numbers prefixed by the letter "S." Thus, S1242 is an article carried in stores only temporarily, and not a standard article of supply in the plant. This saves unnecessary work in classifying, and at the same time an automatic signal is provided to prevent the article from being carried too long. It will also help to indicate automatically when too many of a special article are on hand.

The two general methods of stores classification are:

1. Classification of materials by their nature.
2. Classification of materials by the use to which they are put or the purpose served.

The first method permits a classification that is universal in its nature and is probably necessary in very large, complex plants. When carried to its logical conclusion, it results in somewhat longer symbols than the second method. The second method may result in unnecessary duplication of symbols and some obscurity, but in plants making a standard product it is altogether desirable.

In the first method part of the first sheet of the stores classification would be somewhat as follows:

S—Stores (Purchased Materials)

SA Stationery and Office Supplies
SB
SC
SD Dyestuffs
SE
SL Liquids
SM Metals
SN
SP Paper (other than stationery and printed forms)
SR Rubber and Articles Made Chiefly Therefrom
SS
SX Tools and Appliances
SY Repair Parts for Machinery
SZ Fuels

Under this method the further classification of stores results in a narrower definition of each type of material. Thus SMZ might stand for metal fasteners. That being the case, SMZB would be bolts and SMZBH hexagonal bolts. If made of various materials, such as wrought iron, cast steel, or cold-drawn steel, each variety might be distinguished by a number, so that SMZB1H might mean a wrought-iron bolt. The size of the bolt would be indicated by dimension numbers placed between two of the symbols (not between the last two), as SMZ$\frac{7}{8}$2B1H. This shows that the bolt is $\frac{7}{8}$ inch in diameter and 2 inches long.

In this type of stores classification it is frequently desirable to set up, as major divisions, some types of materials which are particularly important in the business. For instance, in a textile plant operating its own dye house an example would be found in dyestuffs, as indicated above. The nomenclature for stores under this main division might be built up as follows:

SD—Dyes

SDA Acid Dyes
SDB Basic Dyes
SDC Coupled Dyes
SDD Developed Dyes
SDM Mordants
SDN
SDP Naphthol Dyes
SDR

SDA—Acid Dyes

SDAB Acid Dyes, Blue
SDAG Acid Dyes, Green
SDAR Acid Dyes, Red
SDAV Acid Dyes, Violet

SDAB—Acid Dyes, Blue

SDA1B Acid Peacock Blue
SDA2B Alizarine Blue
SDA3B Alizarine Sapphire, etc.

In the second method of stores classification the first sheet will have the materials grouped mainly with reference to the products on which they are used. Such classification is particularly valuable in plants manufacturing standard products, or in plants where a large proportion of the stores are intended, when purchased, for use on one particular product. To illustrate:

SF		SN	Stores for Night Latches
SG		SP	Stores for Padlocks

By this method the stores which are used exclusively on one product are classified by the same general symbol as the product itself, with the prefix S. If we use the same illustration employed to develop the worked-materials nomenclature, it is found that the shackle post for a heavy-duty padlock is designated as SPH4B if the piece is purchased rather than manufactured. If the piece is made in the shop and then put in the storeroom, its worked-material symbol would be PH4B. This illustrates the most valuable advantage of this method of stores classification. Under it, the symbol for stores and worked materials vary only by the prefix of the letter S, provided that the part is used exclusively on one type of product.

The stores used for a variety of purposes must necessarily be classified by nature, rather than by the use to which they are put. The skeleton nomenclature for such stores would be therefore as follows:

SVA Miscellaneous Stores, not otherwise classified
SVB Brass and Articles Made Chiefly Therefrom
SVC Cast Iron
SVL Liquids
SVT Textiles

Mnemonic nomenclature of tools. Tools are classified in much the same manner as stores. The prefix X is usually retained in any accounts dealing with tools, as indicated in the master sheet. This prefix is ordinarily dropped when stamping the symbol on the tool or referring to the tool for shop purposes. For a metal shop, which has most need of an elaborate tool classification, the following is an effective base sheet:

XA Miscellaneous Tools, for special purposes not elsewhere classified.
XB Abrading Tools—All tools for filing, grinding, polishing, rubbing, scratching, scraping, lapping, etc.
XC Clamps and Holding Devices—Clamps and holding devices of all kinds, including bolts and screws, except J & N.
XJ Jigs and Fixtures—Holding devices for specific purposes in connection with the product worked upon. Designed for manufacture of duplicate parts of a given product.
XN Containers—Containers for holding materials, except as classified under C, J, or T.
XP Paring Tools—All tools which remove material from the surface by means of stationary tools and produce the required size through the operation of the machine, except L.

P—Paring Tools

PC Parting Tools
PR Round-Nose Tools
PS Square-Nose Tools
PT Thread Tools

PR—Round-Nose Paring Tools

PRB Blunt Round-Nose Tools
PRS Sharp Round-Nose Tools

PRB—Blunt Round-Nose Tools

PRBL Blunt Round-Nose Tools, Left-Hand Bent
PRBR Blunt Round-Nose Tools, Right-Hand Bent

Mnemonic nomenclature of machinery. Machinery, like tools, usually retains the main classification letter (Y) when its symbol is used to express an account, but drops it when used for shop purposes. Machinery may be classified either by the use to which it is put or by trade name. A portion of the subdivisions, if classification is by the use to which machinery is put, might be as follows:

YB Abrading Machinery—Removes material from surface by abrasion.
YE Energy-Transforming Equipment—Changes energy from one form to another without the intervention of a machine, for example, boilers and transformers.
YK Revolving Cutting Machinery—Removes material by a revolving motion, either in the tool or material, for example, lathes, boring mills.

If the classification is by trade name, which is more common, some subdivisions might be:

YB Boring Mills
YG Grinders
YL Lathes
YP Presses
YT Tumblers
YV Production Centers Which Do Not Include Machines

L—Lathes

LA Automatics
LE Engine Lathes
LH Hand-feed Turret Lathes
LL Low-swing Lathes
LT Threading Lathes, etc.

If there are a number of machines of the same type in the shop, each is designated by placing a number after the machine symbol, as LE7, engine lathe number 7.

Mnemonic nomenclature of buildings. Buildings may be readily classified and symbolized in some such manner as the following:

ZC Conveying Devices
ZE Building Equipment
ZF Office Space
ZM Manufacturing Space
ZP Underground Piping and Tunnels
ZR Power-House Structures
ZT Transmission Lines

Summary of mnemonic nomenclature. Although any portion of the mnemonic scheme of nomenclature can be used separately, and although it may be adapted in any desirable way or used in conjunction with numerical nomenclature, it has been discussed as a complete system. As such, it completely fulfills the objects that were established for standard nomenclature as follows:

1. It gives a measure for the definiteness of functions because by it the duties of individuals can be definitely codified, whether they are executive, clerical, or manual.
2. It provides a definiteness and correct sequence of operations by the use of the product classification in conjunction with proper routing and dispatching methods.
3. By means of the stores and product classifications, it provides for locating materials, both in the storeroom and in process, and makes it easier to keep a perpetual inventory of these articles because of the elimination of much writing of names that would be necessary if there were no symbols.
4. Costs are more readily obtained.

From the master sheet of the classification (Fig. B.1) it has been seen how these primary elements are provided for and how, by the elaboration of the various groups, every item of expenditure is given a symbol. With the correct use of these symbols the allocation of costs is made comparatively easy. It is not the purpose here to illustrate this point, because a more detailed knowledge of the functions and operation of the production department is needed to comprehend fully the true relation between classification and costs. Finally, the system serves as an automatic index for the filing of all "inside shop" information. If information about an operation is to be filed, it is filed by the operation symbol. The same is true of machine specifications and records, product information, cost records of products, and all other matters pertaining to shop routine. It has been pointed out that the functions of individuals were classified. Thus information regarding the individual or his functions can be filed by those same symbols which designate the main classes. Stores records are filed by the stores symbols. Time-study data and blueprints are filed by the symbol of the product to which they apply.

APPENDIX C

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